TECHNICAL AND SCIENTIFIC ACTIVITIES **2009**

CEDEX

CENTRO DE ESTUDIOS Y EXPERIMENTACIÓN DE OBRAS PÚBLICAS

DISEÑO GRÁFICO Y PRODUCCIÓN:
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PRESENTATION

The strong inversion on public works undertaken in Spain requires the compromise of the Government to allocate a significant proportion of the budget to the generation of infrastructures, as well as their ability to plan and manage the overall construction process. Furthermore, it requires the capacity of the industrial bodies –our consulting and contracting companies- to design and build the infrastructures.

On an international level, Spain is viewed as a power in the infrastructure construction sector. This is associated to the excellence and professionalism of those involved in the sector, and to recognized construction know-how. The Ministerio de Fomento (Ministry of Transport) has played an important role by offering Society a series of economic and human resources that contribute to fulfilling the objective of the competitiveness of the Spanish construction sector at an international level. The Ministerio de Fomento, to a large extent, has achieved this through the CEDEX, a body ascribed to the said Ministry.

Likewise, regarding environmental issues, Spain is part of the group of leading countries where environmental management has benefitted from more progress. In this area, the Ministerio de Medio Ambiente, y Medio Rural y Marino (Ministry of the Environment) has played an essential role, again to a large extent through the CEDEX, a body whose operations depend on the Ministry.

The following pages will provide the reader with a detailed description of the work developed during 2009 in each of the Centros de Estudios and Laboratorios integrated in the CEDEX. In this presentation, I believe, it is worth mentioning that this body has been involved in the main policies adopted in Spain in the fields of public works and environmental management.

Indeed, in the field of public works, and in particular in the field of road infrastructures, the CEDEX, working with the Dirección General de Carreteras (General Directorate of Roads) has actively participated in the optimization of road pavement design through the experimental data obtained on the Full-Scale Pavement Test Track. Furthermore, it has contributed to the study of possible uses of secondary and recycled materials on road pavements.

With regards to issues concerning ports, the contribution of this Institution to the political determination to increase the capacity of Spanish ports has been notable. The work of the CEDEX has been developed through conventions and commissions signed with Puertos del Estado (National Ports) for modelling, simulation and experimentation of the operability and safety of port infrastructures. Also worthy of mention is the participation in manoeuvres and emergency simulation, and in the fight against pollution, in collaboration with the Dirección General de Marina Mercante (General Directorate of the Merchant Navy) and SASEMAR.

Within the scope of railway infrastructures and in close collaboration with the Dirección General de Infraestructura Ferroviaria (General Directorate of Railway Infrastructure), ADIF and RENFE, the CEDEX has taken an active role in the development of signals. All high-speed railway infrastructure projects have been equipped with the ERTMS system, so that the development of the AVE (Alta Velocidad Española, Spanish High Speed Railway) in Spain, as opposed to what has been the case in other countries, is carried out inside an open market that incorporates all European suppliers.

The participation of the CEDEX in the verification of the European system, in the consolidation of European guidelines, in the European certification processes for on-board equipment, and on opening of new railway lines, through the validation of levels N1 and N2 is fully recognised. This trust has been strengthened with the commissioning in December of a European project to the partnership formed between CEDEX, DLR, Multitel, RINA and TIFSA. This project has been launched by the European Railway Agency and pursues the definition of the guidelines for the certification tests of the new base line SRS 3.0.0, the future reference for European freight corridors.

Likewise, it is worth mentioning the incorporation of the guidelines for on-board ERTMS systems (Subset-76) certification test into the European Directive for Railway Interoperability, an achievement obtained through the participation of the CEDEX in the European project TEN 2006, together with TIFSA, DLR and Multitel.

Once more for AVE, the Railway Infrastructures Accelerated Test Cell, otherwise known as 'railway box', has been used for assessing embankment sections, studying the performance of the ballast, sub-ballast, underlayer and embankment; the specific points throughout the network suffering from foundation problems; and on viaducts, the structural response under the dynamic loads generated by high-speed trains, in particular the stiffness of the track on the transition points between embankment and viaduct. The important contribution in this respect of the work developed at the CEDEX using the 'railway box' lies in the fact that a week's worth of tests can simulate the circulation of trains equivalent to one year on a track in full use. Thanks to this, it is possible to know the long-term structural performance of railway infrastructure.

Further work done for AVE comprises fatigue and impact tests of various railway rolling-stock manufactured by Spanish railway companies and distributed throughout the globe. These tests are performed using a unique installation known as a Seismic Simulator.

In the field of regulations, the work developed at the CEDEX has contributed to the addition to the Instrucción del Hormigón (Spanish Concrete Code) an annex covering the calculation of concrete made with recycled aggregates obtained from industry or from demolition of structures. Further contribution has been made in the subject of improved durability of structural materials, for example, in bridges and dams.

Regarding the area of transport and planning, an important contribution has been achieved through the establishment of a monitoring indicators system for transport and for its environmental impact (SISTIA).

It is also worth mentioning the support in geotechnical issues provided to the Centros Directivos of the Ministerio de Fomento.

As far as environmental issues are concerned, in particular those issues affecting climate change, the CEDEX has initiated a verification process for the models and guidelines used for developing inventories of polluting emissions released into the atmosphere. The goal of this verification process is to identify the degree of participation of the different agents that take part in the generation of green-house gases, as well as finding specific solutions for each one. Within the scope of the water environment, the CEDEX has taken the responsibility of analyzing the impact of pollution on resources, in particular on water demand, both for irrigation and for human consumption, as well as the impact on the ecological quality of water.

Along the same line, the CEDEX has developed work for identifying environmental impact of the implementation of various projects, in particular those projects derived from interventions for which there is a lack of experience. Such is the case of wind energy installations, marine installation for electricity generation using wind energy, etc.

Regarding water policies, under commission by the Dirección General del Agua (General Directorate of Water), the criteria for delimiting and ecologically classifying Spanish water masses have been studied, in accordance to the Water Framework Directive, thus contributing to Water Planning in Spain.

Furthermore, it is worth mentioning the contribution by the CEDEX to the feasibility studies for water treatment and reuse technologies; in desalination, the analysis of brine dissolution in sea water, the environmental impact of desalination plants and the support provided in the design and construction management of new desalination plants.

Other jobs worthy of mention on water issues are those developed for complying with the new regulation on dam safety and for studying continental and coastal flood areas, which include a risk assessment. The former job comprises the drafting of a technical guide to assess the flow to be used for the design of the drains of all Spanish dams. Lastly, as a complement to the radiological characterization of water masses, both continental and marine, the typology and approach of these activities has been extended. A series of new techniques for identifying and interpreting water problems have started being applied, such as the characterization of water leaks in reservoirs, or the interpretation of underground aquifers recharge or other water phenomena.

Regarding noise, it should be noted that the guidelines and recommendations for the evaluation of environmental noise are currently being drafted, together with the corresponding action plans against noise. Likewise, it is worth mentioning the technical assistance provided to the Ministerio de Fomento as well as to the Ministerio de Medio Ambiente, y Medio Rural y Marino, for complying with Directive 2002/49/CD and with the Noise Law and its Regulations.

Within the field of coasts, and in close collaboration with the Dirección General de Sostenibilidad de la Costa y del Mar (General Directorate of Sustainability of the Coast and the Sea), the CEDEX is working on the physical and numerical modelling for the study of beach stability, on the analysis of coastal and transition water and on the risk analysis of floods.

In issues related to the assessment of environmental impact, the CEDEX has actively collaborated with the Dirección General de Calidad y Evaluación Ambiental (General Directorate of Environmental Quality and Control), supporting compliance with the regulations in-force. This support has included the monitoring and checking of compliance with the environmental requisites/demands of projects subject to the assessment of their environmental impact. It has also included the proposal for contents to be included in environmental impact declarations and in the issue of reports regarding the need to apply the aforementioned procedure to certain interventions.

With the aim to broadcast and extend knowledge of the history of public works, this institution has continued working on historic research and organizing outstanding itinerant exhibitions. One of these exhibitions has been devoted to the life and career of Mr. Carlos Fernández Casado, prominent engineer and essential reference in the field of public works. A further exhibition, entitled 'Spain in the Mediterranean Sea. The construction of space' has presented the influence of our country, both from the technical and engineering perspectives, in other western Mediterranean territories throughout the period defined between the end of the 15th century to the beginning of the 18th century.

All these activities have been coupled with another of the missions assigned to the CEDEX: the dissemination of knowledge; a profitable activity from all points of view, both in the short and long run. This dissemination has been implemented preferably by organizing courses, seminars, conferences or other events, while still utilising other tools, such as internet sites.

It is essential to mention those organization and management aspects involved in the agile response to the varied demands presented to the Centro, always within the administrative complexity and in accordance with the CEDEX statutes. The continued efforts performed for perfecting the most appropriate technical and organizing tools are worthy of mention. These include the decentralization of management procedure, the System Plan, the new on-line resources for better providing services to citizens, etc.

The whole of the work performed by the CEDEX, in my opinion, rests on three main pillars. First of all, the availability of outstanding equipment and facilities, unmatched in the private sector, that enables the Centro to answer the formulated questions providing solutions for the future. This requires an ongoing investment to achieve the demanded technological progress for maintaining and even increasing competitiveness in the sector. In the second place, the availability of very capable staff, civil servants, trainees and other personnel, specialized and very professional, the real architects of the added value generated in this Body in its fields of action. In the third place, the determination of the Ministries the Centro depends on, promoters of a policy to support the application of technology in the sector and the provision of innovative solutions to the daily problems posed within the sector.

The effort carried out by the CEDEX throughout 2009 to fulfil its mission, a mission that appears renewed from year to year, has been crucial for successfully facing the challenges that may appear in years to come, accomplishing the compromise acquired with the Spanish Society.

Madrid, 11th March 2010

Mariano Navas Gutiérrez

THE ORGANISM

STATUS AND FUNCTIONS

The CEDEX is an Autonomous Public Agency, dependent upon the Ministerio de Fomento (Ministry of Transport), while, from an operating point of view, it depends upon the Ministerios de Fomento (Ministry of Transport) and the Medio Ambiente (Ministry of the Environment) (Royal Decrees 1136/2002, dated 31st October, and 591/2005, dated 20th May).

The work developed by the CEDEX focuses on providing specialised technical assistance to the Ministerios de Fomento and de Medio Ambiente. It is a public R&D&i reference centre in the fields of public works and the environment, providing society with the technological progress generated in these fields by a determined dedication to broadcasting and dissemination of knowledge.

Likewise, the Organism meets other requests coming either from other public administrations or from the private sector, it works in close collaboration with similar institutions of other countries on applied research joint programmes, and is present in the international scene, within the framework of Spanish Cooperation for Development Assistance.

DIRECTORIO Y ORGANIZACIÓN

DIRECCIÓN GENERAL

GABINETE TÉCNICO

SUBDIRECCIÓN GENERAL DE PROGRAMACIÓN TÉCNICA Y CIENTÍFICA

CENTRO DE ESTUDIOS HIDROGRÁFICOS

CENTRO DE ESTUDIOS DE PUERTOS Y COSTAS

CENTRO DE ESTUDIOS DEL TRANSPORTE

CENTRO DE ESTUDIOS DE TÉCNICAS APLICADAS

LABORATORIO CENTRAL DE ESTRUCTURAS Y MATERIALES

LABORATORIO DE GEOTECNIA

LABORATORIO DE INTEROPERABILIDAD FERROVIARIA

CENTRO DE ESTUDIOS HISTÓRICOS DE OBRAS PÚBLICAS Y URBANISMO

GOBERNING BODIES

Council

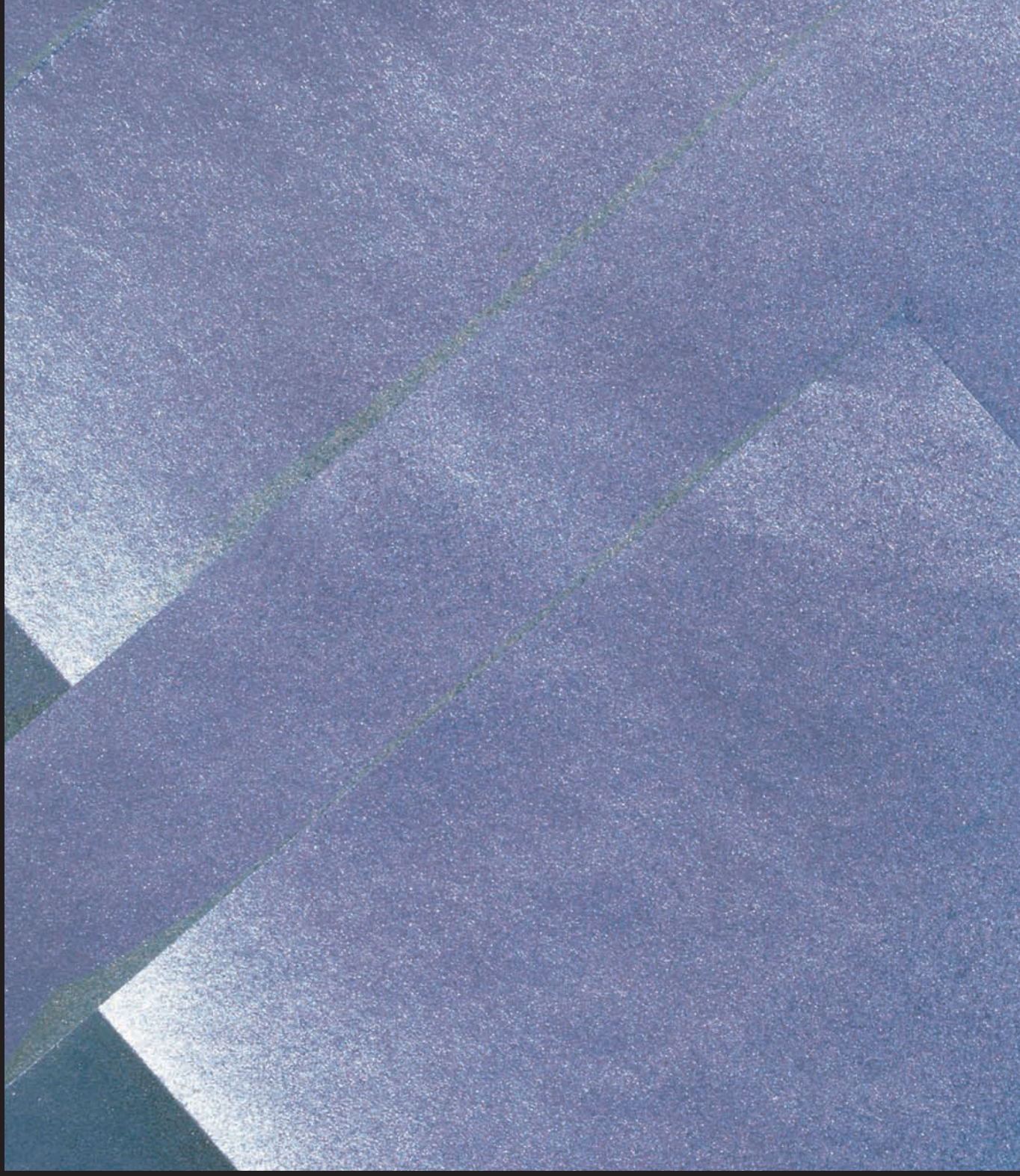
The Council is the body that knows and guides the activities of the Organism. In accordance with Royal Decree 364/2009, dated 20th March, where the statute del Centro de Estudios y Experimentación de Obras Públicas is modified, having been approved by Royal Decree 1136/2002, dated 31st October, published on the BOE on the 31st March, the Council is comprised of the following members:

President:	State Secretary for Planning and Infrastructures.
Vice President:	State Secretary for Rural Environment and Water.
Members:	Deputy Secretary of Fomento.
	General Director of Roads.
	General Director of Railway Infrastructures.
	General Director of the Merchant Navy.
	President of the Public Body State Ports.
	General Director of the CEDEX.
	Deputy Secretary of the Environment.
	General Director of Water.
	General Director of Sustainability of the Coast and the Sea.
	General Director of Environmental Quality and Control.
	General Director of Natural Environment and Forest Policy.
	General Director of the Spanish Office for Climate Change.
	General Director of Research and Management of the National R&D&i Plan.
	General Director of International Cooperation and Institutional Relationships.
	General Director of Architecture and Housing Policy.
Secretary:	*Deputy Director of Technical and Scientific Programmes.*

Board of Directors

The Board of Directors of the CEDEX is the body that assists the General Director in the coordination and administration of the Organism. The president of the Board of Directors is the General Director of the Organism, while the vocals are the General Deputy Director of Technical and Scientific Programmes, the Directors of the Centro de Estudios Hidrográficos, the Centro de Estudios de Puertos y Costas, the Centro de Estudios del Transporte, the Centro de Estudios de Técnicas Aplicadas, the Laboratorio de Geotecnia, the Laboratorio Central de Estructuras y Materiales, as well as the Manager of the Centro de Estudios Históricos de Obras Públicas y Urbanismo and the Director of the Technical Cabinet, who acts as Secretary.

President:	*General Director of the CEDEX.*
Vocals:	*Deputy Director of Technical and Scientific Programmes.*
	Director of the Centro de Estudios de Puertos y Costas.
	Director of the Centro de Estudios Hidrográficos.
	Director of the Centro de Estudios del Transporte.
	Director of the Centro de Estudios de Técnicas Aplicadas.
	Director of the Laboratorio Central de Estructuras y Materiales.
	Director of the Laboratorio de Geotecnia.
	Gerente of the Centro de Estudios Históricos de Obras Públicas y Urbanismo.
	Director of the Technical Cabinet.



GABINETE
TÉCNICO

SUMMARY OF ACTIVITIES OF THE R&D TECHNICAL MANAGEMENT UNIT IN 2009

Throughout 2009, the CEDEX's R&D Technical Management Unit performed the tasks of coordination, management and dissemination of research in connection to the projects financed in the in concourses run in 2006 and 2007.

DISSEMINATION

As in the previous year, the 2nd Conference for the Presentation of R&D&i projects took place between the 24th and 26th of February 2009, in the conference hall of the Centro de Estudios de Técnicas Aplicadas.

The objective of this conference is to favour the fast introduction of research results into transport policies of the Ministerio de Fomento (Ministry of Transport) and into the sector in general. They aim to inform the relevant agents about fulfilment of financed/subsidized activities, broadcasting the activities themselves, as well as the results of research projects. Lastly, they focus on interrelating the different working groups to build a knowledge base, coherent and progressive, contributing in this fashion to establishing a reference for new research lines or for supporting existing ones.

It is worth mentioning that 30 papers were presented in this conference, and a total of 116 participants were inscribed. As in earlier years, the papers were grouped under four subjects: three papers on the subject of Maritime Transport and Port Terminals, twelve papers on the field of Transport Policy and Intermodality, eight on issues related to Roads and seven on the subject of Railways. The content of these papers was published on the website www.cedex.es/idipeit and was included in the documentation provided at the conference, together with the summaries of the projects from both concourses that were underway at the time.

As a result of this event, the CEDEX was invited to the 13th European Platform on Mobility Management, held in San Sebastián (Guipúzcoa) in May 2009. The results of the projects *Improving bus networks and inter-modality, Variables which influence accidents of bicycles: models and designs, Towards a walkable city* and *Pro-bici,* all of them related to the theme of the Platform, were presented in summarized versions.

PROJECT ACCOUNT

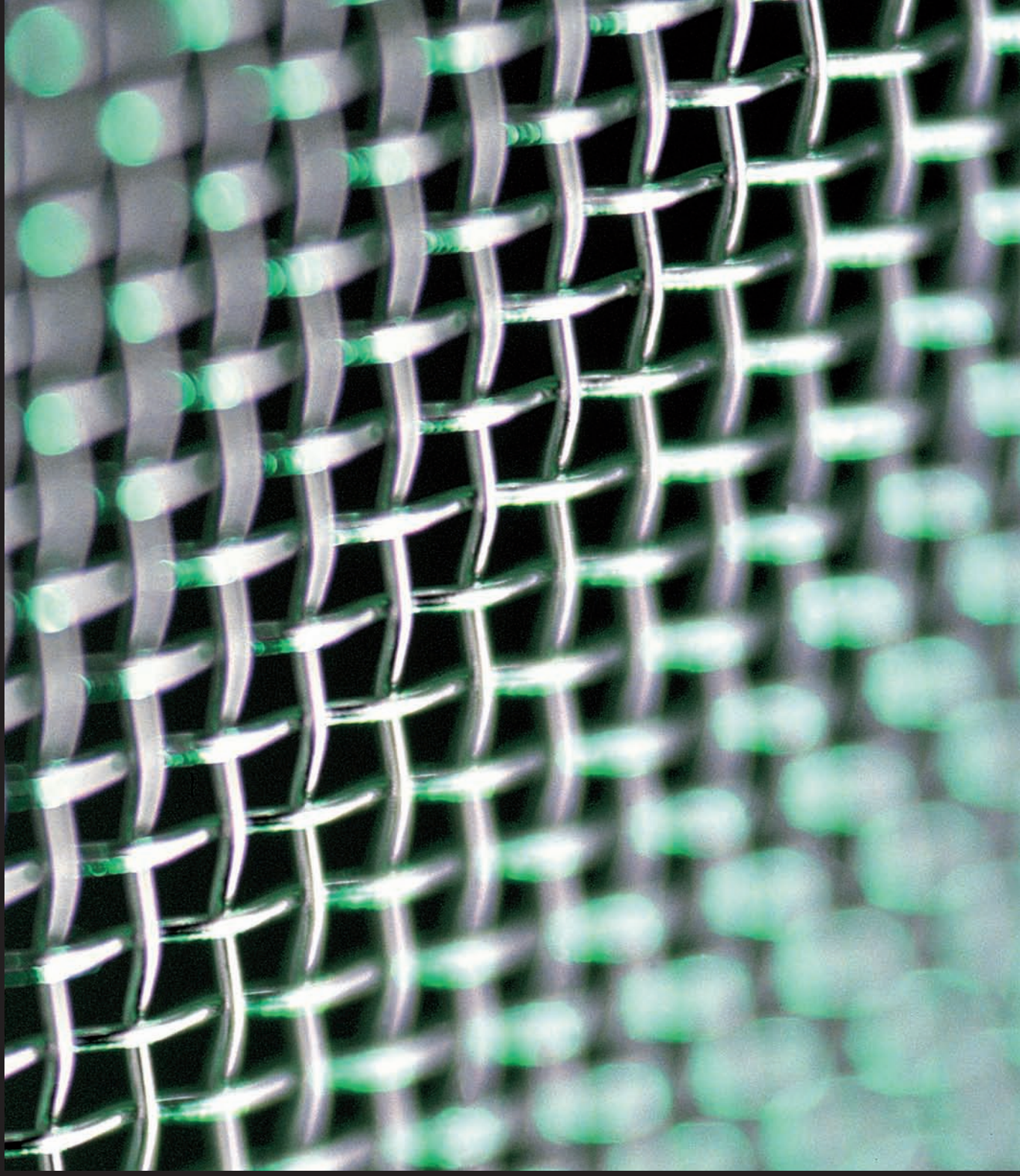
Throughout 2009, 16 projects have been completed while a further 15 are still underway. Three of the completed reports relate to the field of Maritime Transport and Port Terminals: *Port-rail integration: advise, methodology and case studies, Operation and simulation models to optimize port terminals and Security tools for risk management in port facilities*.

Eight projects have been completed within the area of Transport Policy and Intermodality: *Pre-normative research on the management of shadow toll, Integration of external trade and transport statistics, Socioeconomic and financial appraisal for transport project and policy, Improving bus networks and inter-modality, Towards a walkable city, Model for evaluating the transport system energy, and the problems involved, Supply chain collaboration models. (SCMIntegral)* and *Spanish road pricing model*.

Three projects were completed on the subject of Roads: *Tools for safe roadway and roadside design, Variables which influence accidents of bicycles: models and designs and Light signals use for safety in road tunnels*.

Lastly, in the field of Railways, the following projects have been completed: *Mid and long-term behaviour of railway track structures on ballast and slab and Reduction of the rail track vertical stiffness variability.*

The reports and documents generated in completed research projects are published on the website www.cedex.es/idipeit and are available in the CEDEX's data base CATA.



SUBDIRECCIÓN GENERAL DE PROGRAMACIÓN

TÉCNICA Y CIENTÍFICA

HUMAN RESOURCES

The total staff on the 31st December 2009 was 714. This represents an increase of 12 employees with respect to the number registered at the beginning of the year. Throughout the year, 61 new members joined CEDEX while 49 people left, including 14 retirements. Graduate level people at the end of 2009 comprise 48% of the total number of staff, indicating continuous progress in this indicator as the figure that in 2005 was scarcely 42%.

Unfortunately, the expectations for the near future do not point towards the upkeep of the number of staff. Indeed, the severe restriction, aimed at containing public expenditure, that was introduced in the Public Employment Offer for 2009 for replacing retired staff (a maximum of only 30% of retired staff to be replaced), together with that to be applied in the Offer for 2010 (15%), will have, most likely, an important impact on the number of staff, that tends towards decline due to retirements.

As a result of these restrictions, the Public Employment Offer approved for 2009 allocated only 9 posts for new civil servants to CEDEX. An even smaller figure is expected for 2010. These restrictions willl complicate the recruitment of new people with the required background and specialization to meet the specific needs of CEDEX.

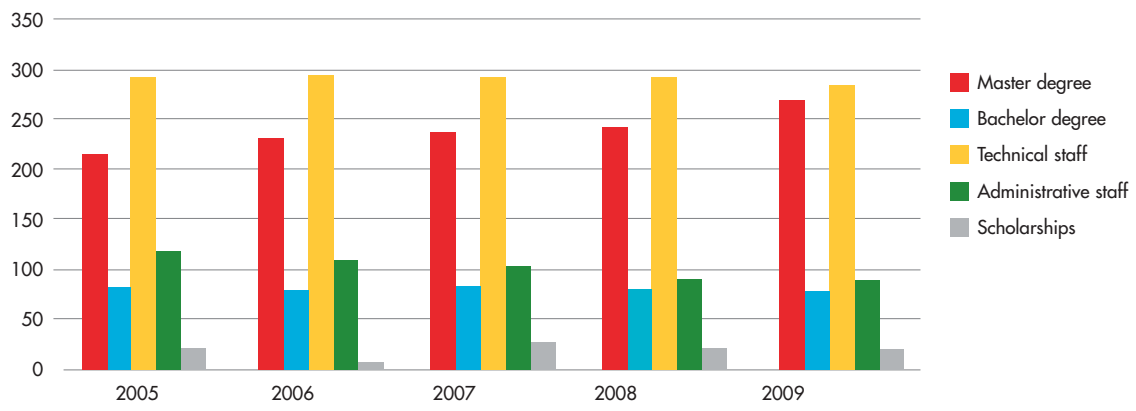
Regarding staff working under temporary research contracts, the total number of staff added was up to 64 by the end of the year. Throughout the year, twenty four new researchers joined CEDEX under this type of contracts.

It is worth pointing out that, as requested by CEDEX, it was approved the establishment of a quota for hiring 34 new researchers with temporary contracts during 2010. This new quota procedure will allow a more flexible arrangement of future recruitment processes, better adapted to the specific needs of CEDEX. .

With respect to the scholarships programme, a new call for training research staff was held in 2009. This programme provides technical and financial support for the development of PhD thesis on matters and activities of CEDEX. A total or 12 positions were included in the call, of which 10 were awarded. At the end of the year, the total number of scholars added up to 22, most of them pursuing their PhD.

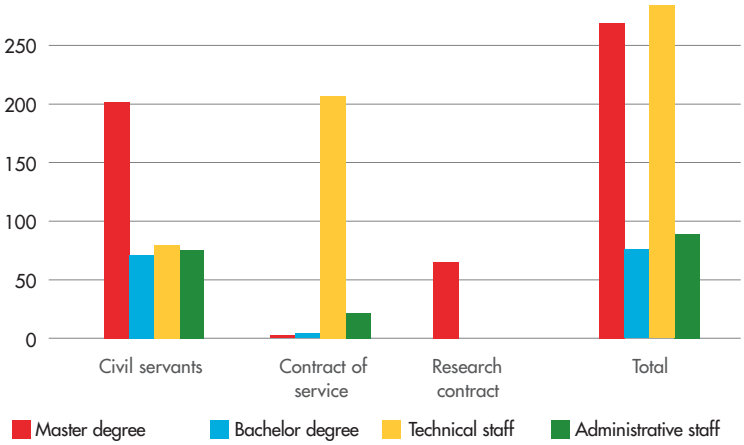
EVOLUTION OF STAFF BY PROFESSIONAL CATEGORIES

Category	2005	%	2006	%	2007	%	2008	%	2009	%
Master degree	214	30,5	228	32,2	235	33,1	241	34,3	266	37,3
Bachelor degree	80	11,4	79	11,2	84	11,8	81	11,5	77	10,8
Technical staff	290	41,4	293	41,4	289	40,6	290	41,3	283	39,5
Administrative staff	117	16,7	107	15,1	103	14,5	90	12,8	88	12,3
Total	**701**		**707**		**711**		**702**		**714**	
Scholarships	21		8		26		21		22	
Total	**722**		**715**		**737**		**723**		**736**	

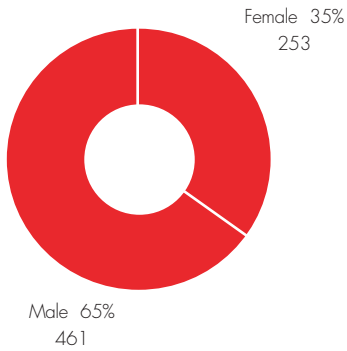


STAFF ON 31-12-2009

	Civil servants	Contract of service	Research contract	Total	% Total	Female	% Female
Master degree	201	2	63	266	37,3	105	39,5
Bachelor degree	74	2	1	77	10,8	26	33,8
Technical staff	81	202	0	283	39,6	59	20,8
Administrative staff	76	12	0	88	12,3	63	71,6
Total	**432**	**218**	**64**	**714**	**100**	**253**	**35,4**



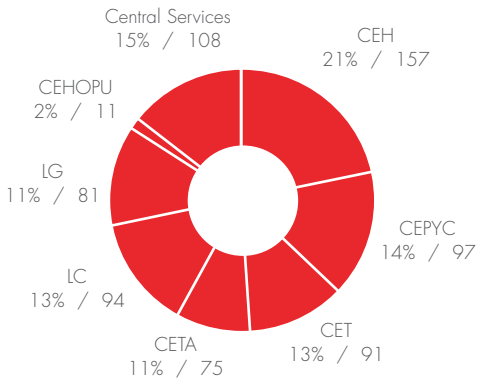
DISTRIBUTION BY GENDER - Male Female



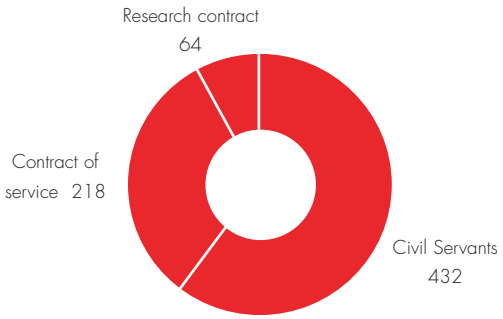
DISTRIBUTION OF STAFF BY CENTRE AND CATEGORY ON 31-12-2009

	CEH	CEPYC	CET	CETA	LC	LG	CEHOPU	Central Services	Total
Civil servants	85	62	44	46	53	41	10	91	432
Contract of service	45	24	35	23	39	35	1	16	218
Research contract	27	11	12	6	2	5		1	64
TOTAL	157	97	91	75	94	81	11	108	714

DISTRIBUTION BY CENTRE



DISTRIBUTION BY TYPE OF CONTRACT



MOST RELEVANT STAFF SELECTION PROCESSES HELD IN 2009

Escala de Técnicos Facultativos Superiores de Organismos Autónomos
- Positions for CEDEX:
- Ministerio de Medio Ambiente (Ministry of the Environment): 2

Cuerpo de Ingenieros de Caminos, Canales y Puertos
- Positions for CEDEX: 3

Cuerpo Superior de Sistemas y Tecnologías de la Información
- Positions for CEDEX: 1

Cuerpo de Gestión de Sistemas e Informática
- Positions for CEDEX: 1

Cuerpo Especial Facultativo de Marina Civil
- Positions for CEDEX: 1

Personal titulado superior contratado para Proyectos de Investigación
- Call: 9 th March 2009
- Positions offered for CEDEX: 3
- Positions awarded: 3 positions*

Para la realización de becas de formación de personal investigador en actividades y materia de la competencia del CEDEX
- Call: 25th May 2009
- Positions offered: 12
- Positions awarded: 10

* 21 further positions awarded as a result of the call published in October 2008.

FINANCIAL MANAGEMENT

The total budget of CEDEX for the year 2009 amounted to 47,21 Million Euros. It should be noted that the Ministerio de Economía y Hacienda declared on the 24th April 2009 the unavailability of an amount of 3,86 Million Euros of the initial budget. This forced the reduction of the initial investment budget by the same amount.

According to the attached table, 88% of the budget expenditure was used, amounting to 41,42 Million Euros. In relation to Chapter 6 'Investments', the expenditure reached 7,7 Million €, equivalent to 98% of the final budget. It must be highlighted that, as stated above, the unavailability of a portion of the initial budget had a direct effect on investments, resulting in a considerable reduction, of nearly two million Euros, of the investment performed in the previous year.

With respect to the income from CEDEX commercial activities, this amounted to 18,55 Million Euros (VAT exclusive), 21% less than the preceding financial year. After deducting the expenditure associated with those commercial activities (purchases and wages of contracted research staff), that amounted to 6,17 Million Euros, the final net result of commercial operations added to 12,38 Million Euros, representing a fall of 23% with respect to the 16,05 Million Euros reached in the previous financial year. This was caused, mostly, by the delay generated by different reasons in the renovation of various Commissions that expired throughout the year.

The total income generated through the commercial activity of the Organization brought the self-financing rate in 2009, including investment, to the 40%. This a considerable decrease from the 49% reached in 2008, and brings the level back to that obtained in the 2007 financial year (41,4%).

Regarding the activity carried out throughout the financial year, a total of 146 interventions were completed out of the 471 under development within the CEDEX to meet the different commissions, as well as the internal projects. As a result of this work, 414 reports were issued, of which 114 were final reports.

2009 REVENUE BUDGET (THOUSANDS EUROS)

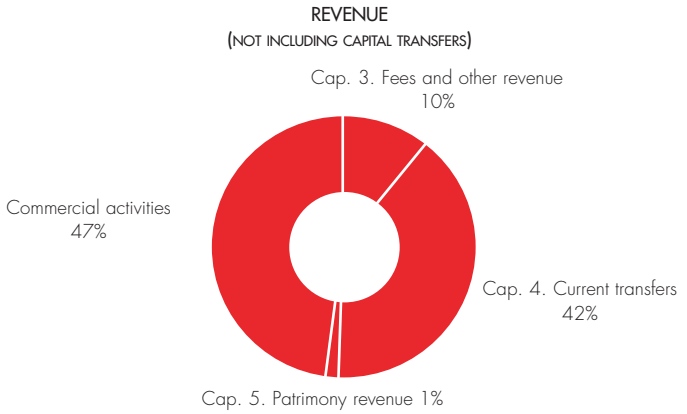
Concept	Final budget	Recognized rights	Execution %
31. Public prices	600,00	494,73	82
33. Goods sales	73,00	80,17	110
38. Repays	10,00	227,15	No representative
39. Other revenue	340,00	2.909,87	No representative
Cap. 3. Fees and other revenue	**1.023,00**	**3.711,92**	**No representative**
40. Current transfers from Ministry of Transport	16.123,39	16.123,39	100
41. Current transfers, others		99,68	
Cap. 4. Current transfers	**16.123,39**	**16.223,07**	**101**
52. Deposits and delay interests	90,00	152,67	No representative
57. Commercial activities outcome	11.000,00		
58. Working fund deviations	14.386,72		
Cap. 5. Patrimony revenue	**25.476,72**	**152,67**	
700. Capital Transfers from Ministry of Transport	4.550,47	4.520,47	99
701. Capital transfers, others		576,52	
Cap. 7. Capital transfers	**4.550,47**	**5.096,99**	**112**
Cap. 8. Financial assets	**38,32**	**38,23**	**100**
TOTAL REVENUE BUDGET	47.211,90	25.222,88	No representative
Commercial activities	**20.700,00**	**18.599,44**	**90**

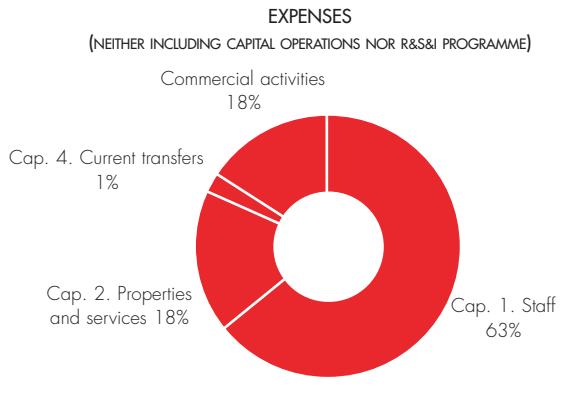
2009 EXPENSES BUDGET (THOUSANDS EUROS)

Concept	Final credit	Contracted obligations	Execution %
10. Directives	60,60	60,52	100
12. Civil Servants	15.974,24	14.285,30	89
13. Research staff	4.958,52	4.746,58	96
15. Production bonus	1.162,42	1.162,35	100
16. Social benefit dues	5.090,67	4.608,09	91
Cap. 1. Staff	**27.246,45**	**24.862,84**	**91**
20. Renting	33,18	15,03	45
21. Repairs and conservation	1.698,22	1.523,66	90
22. Materials, supply and others	6.612,01	5.1104,56	77
23. Per diem's	973,49	818,44	84
24. Publications	351,68	273,65	78
Cap. 2. Goods and services	**9.668,58**	**7.741,34**	**80**
48. Transfer to families	1.010,01	442,09	44
49. External	73,13	64,12	88
Cap. 4. Current transfers	**1.083,14**	**506,21**	**47**
62. Investment for new services*	4.478,67	4.221,95	94
63. Investment for replacement	2.422,17	2.513,11	104
64. Immaterial investments *	1.014,57	979,12	97
Cap. 6. Investment	**7.915,41**	**7.714,18**	**97**
Cap. 7. Capital transfers	**1.260,00**	**556,55**	**44**
Cap. 8. Financial assets	**38,32**	**38,32**	**100**
TOTAL EXPENSES BUDGET	47.211,90	41.538,47	88
Commercial activities	**9.700,00**	**6.165,27**	**64**

* Sum of Programmes 451M and 467B

2009 BUDGET EXECUTION

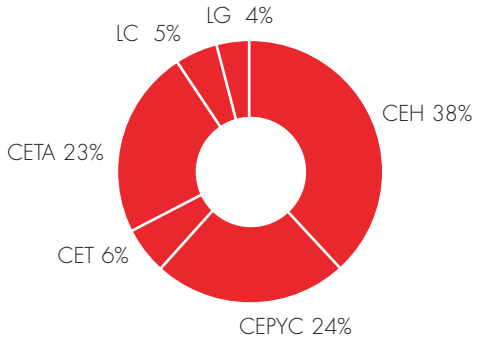




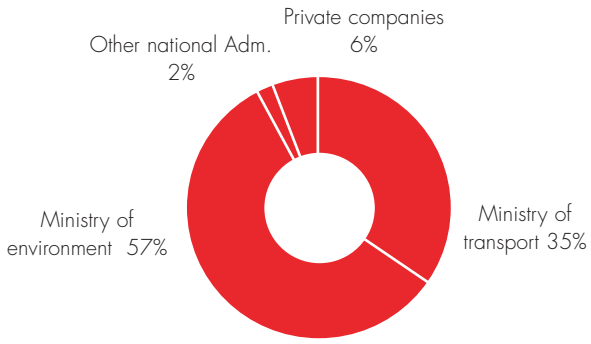
COMMERCIAL ACTIVITIES TOTAL REVENUE. DISTRIBUTION BY CENTER AND DESTINATION (YEAR 2009)

	CEH	CEPYC	CET	CETA	LC	LG	TOTAL	% INSTITUTION/TOTAL
MINISTRY OF TRANSPORT		2.952.337	936.100	114.166	637.207	693.840	5.333.650	**24**
MINISTRY OF THE ENVIRONMENT	8.229.476	1.752.500		4.135.545	108.269	142.589	14.368.379	**66**
OTHER NATIONAL ADM.	724		92.700	316.488	147.848	5100	562.860	**3**
REGIONAL AND LOCAL ADM.			90.000	4.510		31.900	126.410	**1**
PRIVATE COMPANIES	110.535	457.538	256.029	307.722	224.573	49.371	1.405.768	**6**
TOTAL	**8.340.735**	**5.162.375**	**1.374.829**	**4.878.431**	**1.117.897**	**922.800**	**21.797.067**	**100**
% CENTRE/TOTAL	**38%**	**24%**	**6%**	**23%**	**5%**	**4%**	**100%**	

DISTRIBUTION BY CENTRES



DISTRIBUTION BY DESTINATION



ORGANIZATION AND MANAGEMENT

Perhaps the most relevant issue of the year 2009 was the modification of the Statutes of CEDEX set on Royal Decree 364/2009, dated 20th March and published in the Boletín Oficial del Estado (BOE) the 31st of March. The modification includes, the declaration of CEDEX as an internal technical service of the institutions belonging to the State Central Administration and also most of the organizations and entities connected to it. Thus, these organizations can commission services to CEDEX in an *in house providing mode*.

This declaration as an internal technical service is a consequence of the adaptation to the requirements of Law 30/2007 for Contracts in the Public Section, which also requires that the services developed internally within a public institution should also be priced according to *Tarifas* (a kind of price list). Such *Tarifas*, which include direct and indirect costs, as well as a trade margin, were approved by resolution of the Secretario de Estado de Planificación e Infraestructuras (Secretary of State for Planning and Infrastructure) on 5th May 2009 (published in the BOE of 1st of June).

In parallel to approving these Tarifas, a new Resolution dated 22nd October 2009 was published in BOE on the 23rd of November. This Resolution establishes the public prices applicable to services offered to clients other than the State General Administration (other public bodies and private companies). These public prices were established according to the same structure followed for *Tarifas*, thus unifying in a single structure the whole of the services developed by CEDEX for its different clients.

The establishment of both, public prices and *Tarifas*, represents a significant milestone, consolidating the different instruments (conventions, contracts, etc) through which CEDEX carries out its services for institutions and companies.

The work for modernizing the management system continued during 2009, adapting and introducing different management tools. It is worth mentioning the completion of the project for stablishing analitical cost accounting (CANOA), endorsed by the IGAE. This system will enable the close monitoring of the overall costs generated in the development of the activities. Also worthy of mention is the introduction of a Control Panel tool that will allow the monitoring of the most important management indicators.

Likewise, the implementation of the Information Systems Plan continued. Among other projects, a series of on-line services have been implemented to enable citizens, institutions and companies to access remotely through internet some of the services offered by CEDEX, such as to apply to a scholarship or to register in a course.

CENTRO DE ESTUDIOS

HIDROGRÁFICOS

LABORATORIO DE HIDRÁULICA

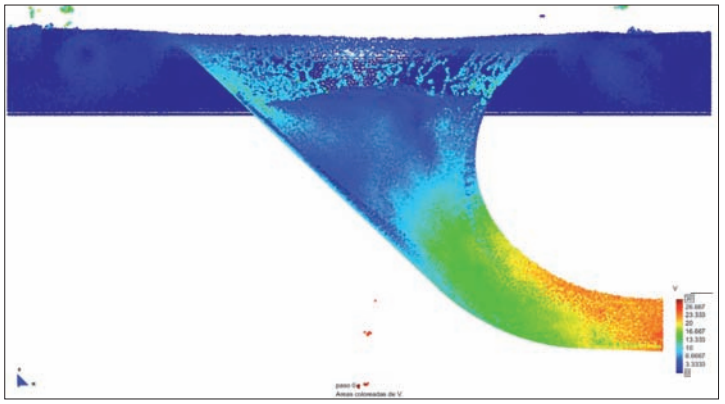
2009 has been a crucial period for the Laboratorio de Hidráulica (Hydraulics Laboratory), as this has been the year for the conclusion of the work included in the Convention with the Dirección General del Agua (DGA, General Directorate of Water) of the Ministerio de Medio Ambiente y Medio Rural y Marino (MARM, Ministry of the Environment and marine and Rural Affairs) for the "Technical Assistance, Research and Technological Development in the field of Continental Hydraulics". This Convention had been signed in 2003 and has served as framework for the development of a large number of technical studies in the fields of dam safety and river hydraulics.

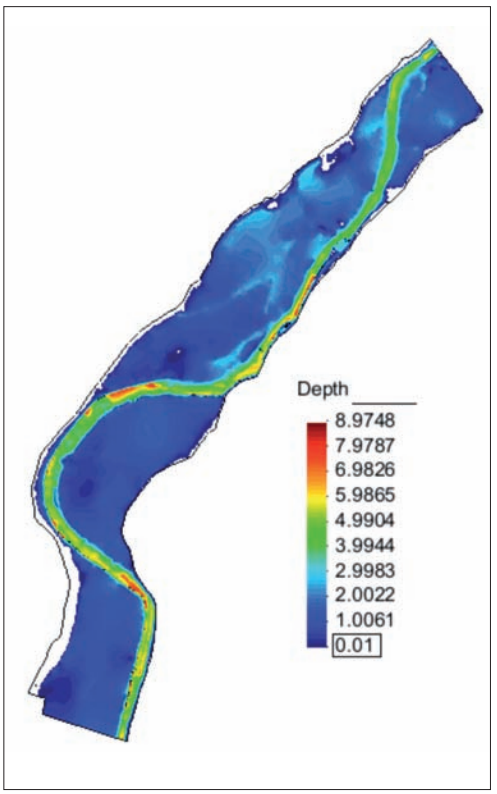
In particular, under the framework of the aforementioned Convention, the Laboratorio has completed the studies using physical models of the spillways of the dams of Amadorio (Júcar Basin Authority), Peña del Águila (Guadiana Basin Authority), Huesna and San Calixto (both under the management of the Agencia Andaluza del Agua (Water Authority of Andalucía). During this year, a preliminary study for the enlargement of the spillway at the Calanda dam (Ebro Basin Authority) has also been developed. This study, however, will continue in 2010. Under other administrative frameworks, different from the aforementioned Convention with the DGA, at the Laboratorio de Hidráulica a number of physical models have been created during 2009 for the spillways of the new Regajo and Terroba dams (both on the Ebro Basin Authority). Furthermore, the Laboratorio has collaborated on the physical modelling of the spillway of the Villalba de los Barros dam (Guadiana Basin Authority).

Regarding physical models for river hydraulics analysis, the following studies were completed: study of the mouth of the river Júcar at the Estany de Cullera and study of the channelling of the Quisi and Pou Roig ravines through the city of Calpe/Calp, both projects for the Júcar Basin Authority. Furthermore, progress has been made on the study of the meander of Quinzanas on the river Narcea (Cantábrico Basin Authority). Last in this chapter of physical modelling during 2009, it is worth mentioning the completion of a hydraulic study of the localized erosion at the pad foundations of the bridge Vidin-Calafat in the river Danubio. Again in the area of urban river hydraulics, the Laboratorio has started in 2009 a collaboration with the Agencia Andaluza del Agua for the hydraulic study of the river Guadalmedina passing through the city of Málaga.

Together with the aforementioned jobs in the scope of physical modelling, during 2009 the Laboratorio de Hidráulica has also done important work on mathematical modelling, in particular in the field of river hydraulics. Therefore, in the first place, the collaboration with the Universitat Politècnica de Catalunya (UPC) and the Universidade da Coruña, started in 2007, has continued. This collaboration pursues the development of a computational calculation model for flood wave flows. The first version of the model (to be called IBER) has been finalised and will be presented at the beginning of 2010. This model is already being applied in various projects in the Laboratorio de Hidráulica: river Tiétar between the Rosarito and Torrejón dams (Tajo Basin Authority), Quinzanas meander in the river Narcea (Cantábrico Basin Authority) and mouth of the river Júcar at the Estany de Cullera (Júcar Basin Authority). Still in this field of numerical modelling, worthy of mention is the progress made by the Laboratorio de Hidráulica in the development of its own codes for a Smooth Particle Hydrodynamics (SPH) Lagrangian model, applied during this year to the analysis of the spillway at the Calanda dam, complement-

Physical model of the spillway at the San Calixto dam (Agencia Andaluza del Agua).





TOP
Physical model of the river Jucar mouth at the Estany de Cullera (River Jucar Authorities).

BOTTOM
Lagrangian numerical model of the spillway at the Calanda dam (River Ebro Authorities).

RIGHT
Numerical model of the meander of Quinzanas in the river Narcea (Northern River Basin Authorities).

ing the study of physical models described above. In the field of environmental hydraulics, the Laboratorio has made very important progress on the studies of fishways in dams and diversion dams, a work started a number of years ago. The Laboratorio has collaborated with the Universidad Complutense de Madrid (UCM), the Universidad Politécnica de Madrid (UPM) and the Universidade da Coruña, perfecting the model of a fishway built in the Laboratorio, used from the month of May for experiments with cyprinids (barbels) and from December with salmonids (trouts).

In the field of research and technological development, it is worth mentioning the participation of the Laboratorio de Hidráulica during 2009 in three important projects within the R&D&i National Plan in the area of dam safety: the XPRES project about the performance of earth dams subject to floods larger than the design flood, with overflow (in conjunction with the UPM and Centro internacional de Métodos Numéricos en Ingeniería (CIMNE)); the ALIVESCA project for studying the behaviour of stepped spillways w(in collaboration with the UPC and the company Dragados) and a third project for studying the increase of draining capacity in existing dams by special spillways, siphons and labyrinths (in conjunction with the UPM and the company Jesús Granell SA).

Also noteworthy in the area of research is the consolidation of the activities of the Plataforma Tecnológica de Laboratorios de Hidráulica de España (PTLHE, Spanish Technological Platform of Hydraulics Laboratories), renamed Red de Laboratorios de Hidráulica de España (RLHE, Spanish Network of Hydraulics Laboratories), created in 2008 and bringing together our Laboratorio de Hidráulica and the rest of Spanish Laboratories, mostly university laboratories, with the goal of strengthening R&D&i in this field. Two seminars were held in 2009 with the participation of experts from the institutions included in the Network.

In the field of dissemination of knowledge, the Laboratorio de Hidráulica organised various events throughout 2009. Worth mentioning are the Jornadas de Ingeniería del Agua (Water Engineering Congress) (in conjunction with the Fundación para el Fomento para la Ingeniería del Agua and -the Spanish Chapter of the International Association of Hydro-Environment Engineering and Research (IAHR)-) that attracted the interest of about 300 professionals in the subject, or the participation in the 5th World Water Forum, held in Istanbul (Turkey).

In the area of regulations, the drafting up of the Guía Técnica sobre Depósitos para abastecimiento de agua potable (Technical Guide for Deposits for Purified Water Supply) (commissioned by the MARM) has been completed. This document is expected to be published in 2010. Furthermore, the work on the Manual de Balsas (Manual for Reservoirs) (chapter

on hydraulic components) has been finalised. This Manual will be published by the Comité Nacional Español de Grandes Presas (Spanish National Committee for Large Dams).

DIRECTORATE OF WATER AND ENVIRONMENTAL STUDIES

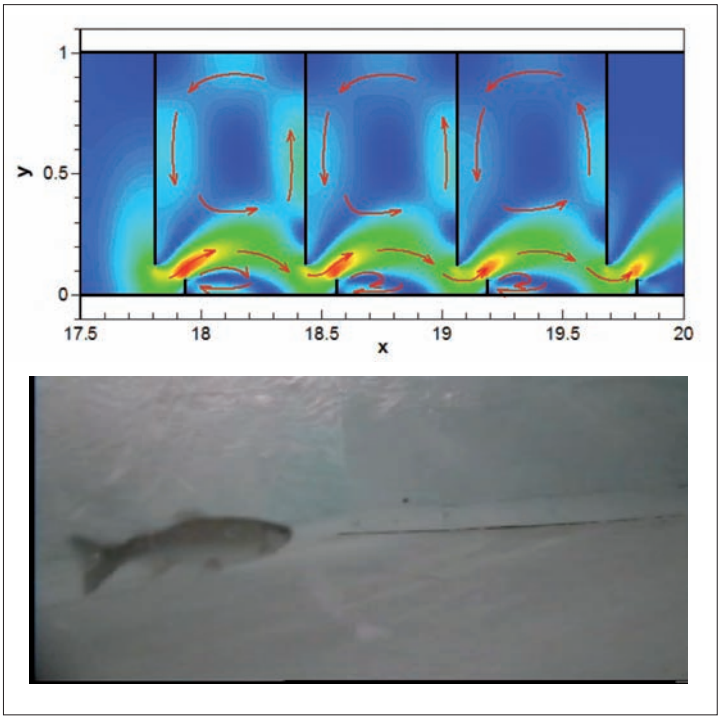
In the **Planning and Studies Division,** the Centro has provided further support to the hydrological planning process, currently underway.

Regarding the definition of the boundaries of river basin districts, the Division has revised the remarks made by some River Basin Authorities on the proposal for the definition of boundaries between inter-communitarian river basin districts, drafted in 2008 obtained from the digital maps made by the Instituto Geográfico Nacional (Spanish Geography Institute) at national scale. Furthermore, under the request of some River Basin Authorities, certain small areas have been studied in greater detail.

The Planning and Studies Division has taken part in the definition of the contents to be included in the Report of river basin plans, as well as in the Annex devoted to operating systems. The Division has also participated in the analysis of the possible impact of the environmental flows regimes, to be implemented in accordance with the prescriptions of the Instrucción de Planificación Hidrológica (Technical Instruction of Hydrological Planning), on the national electric supply system, focusing on the possibility of the regime affecting the safety of the supply.

As far as the development of new guides is concerned, the technical guide for the definition of measures to be included in the programmes of the river basin plans is almost completed. Many of the measures proposed in the Instrucción de Planificación Hidrológica (Technical Instruction of Hydrological Planning),as likely to be implemented to meet the objectives set in the river basin plans have been analyzed, providing a method to estimate investment and operation costs. Thus, the study related to storm water attenuation tanks has been completed, as well as the definition of the options aimed for increasing the availability of resources, tackling the issue of desalination of sea water. The environmental measures have also been finalised, including the interventions on wet lands, the protection of endangered species and the control of alien species.

In relation to the Convention on cooperation for the protection and sustainable use of the water of the Spanish-Portuguese river basins, the Division has once more taken part in the working groups dealing with the Water Framework Directive and with the flow regime established for the development of the Convention.



Velocity field for a fishway and experimentation of the fishway with cyprinids in the Laboratorio de Hidráulica.

Lastly, the work for analysing the impact of climate change on the water resources availability has been pushed forward substantially by bringing up to date the simulation schemes for inter-communitarian river basins, dating from 1998. The criteria for the selection of reservoirs to be considered in the scheme have been established so that new dams have been added. The environmental restrictions expected to be considered in the future river basins plans have been identified in order to be included in the new schemes. The aforementioned elements helped in determining the locations where it is necessary to evaluate the natural water resources series corresponding to the different climate change scenarios, in order that, as results of the simulation, the available resources can be obtained at each scenario.

The Sustainable Water and Land Management Division has carried on with the study of the potential effects of climate change on water demand. Concerning irrigation water demand, this Division has revised and completed the calculations for the different climate models considered, at the areas and for the crops selected throughout Spain. In addition, the generic crop simulation model CROPSYST has been used. Furthermore, strategies for adaptation have been defined.

Logo of the Water Engineering Conference.

Regarding urban water demand, further work has been done on the analysis of climate change impact on household demand, considered at a municipal scale, for the whole of Spain. Water demand for irrigation of green areas has also been studied by adapting the procedures given by FAO for the calculation of crop water requirements to the specific plants present in green areas. Furthermore, the study for possible adaptations has been started.

With relation to the Programa de Formación Iberoamericano (Ibero-American Training Programme) on water issues, this Division has provided support for the implementation of fifteen courses and has started works on the development of an interdisciplinary network for transfer of knowledge regarding water. Two R&D&i projects are currently under development. The first project deals with water pollution related to nitrates coming from agricultural activities, while the second project is focused on the definition of irrigation measures that can contribute to improving water status.

In 2009, the **Water Environment Division** has obtained AENOR's quality certificate ER-0319/ 2009, in accordance with the regulation UNE-EN ISO 9001:2008, for the design, development and performance of physical and chemical analysis using chromatographic, spectrometric and spectrophotometric techniques, as well as elemental analysis of water, mud, soil and sediments, and toxicity analysis of continental water.

Samples have been taken from a number of water supply reservoirs in order to obtain the molecular definitions of cyanobacteria that could potentially generate toxins. Brine shrimps (Artemia Salina) bio-assays have been carried out on and a number of identification procedures have been implemented to determine cyanobacteria species, as well as other phytoplankton found in the reservoirs. The reservoirs studied are Pontón Alto, Serones and Las Vencias (Duero river basin), Beceas, Miraflores and Navalcán (Tajo river basin), Alange, Gasset and Vega de Jabalón (Guadiana river basin) and Arquillo de San Blas (Turia river basin).

The MARM has published the study 'Preliminary Ecologic Bases for the Conservation of Habitats of Communitarian Interest in Spain'. This Division has coordinated the team working on running water, devoted to obtaining their ecologic characteristics and to establishing the methodologies for the evaluation and monitoring of their state of conservation.

A further field of work has been the evaluation of climate change impacts on the ecologic conditions of water masses. Within this area, this Division has developed a statistical methodology for estimating ecological optimum values and tolerance ranges for environmental variables for different species, as well as for selecting biological indicators with greater sensitivity against temperature changes or other variables. A mathematical model for the transfer of air temperature to water temperature as a function of the ecological classification of river water masses has been developed. Likewise, the Division has put in use a predictive model that is to be applied to the response simulation of communities under future stages of climate change, having selected the environmental variables and biological taxa used in the model.

Further effort has been put on the work previously underway for updating the classification of superficial water masses, as well as for updating the design of the classification system for the ecological condition. The revision of the biological data base of the DGA has been incorporated into these classification systems, and a number of documents have been drafted, versed on measuring and sample-taking protocols, as well as on the reference conditions, referred in particular to phytoplankton. Sample-taking campaigns have been completed in a number of rivers, including the rivers Avia, Cabriel, Guadiana, Guadalquivir, Iregua, Jarama, Najerilla, Porma, Sorbe, Tea and Torio. The objective of these campaigns is to analyse altered water downstream from reservoirs.

The paleolimnologic laboratory analysis of sediment samples taken from a number of Antarctic lakes has been started. This study lies within the framework of research projects for the study of non-marine aquatic ecosystems in Polar Regions, in particular in the Byers Peninsula and Livingston Island.

The Division has been responsible for the coordination of intercalibration tasks in the working group for study of phytoplankton in Mediterranean lakes and reservoirs. This work has been done in collaboration with the European Committee for Standardization. Furthermore, the Division has taken part in the phytoplankton group of the WISER project, under the 7th Framework Programme of the European Commission (EC). The Mediterranean Phytoplankton Workshop took place in the Centro de Estudios Hidrográficos in October. This workshop hosted discussions of the various phytoplankton analysis method-

ologies in use in the different Mediterranean countries.

The Water Quality Laboratory has continued working on the definition of different analytical parameters (main ions, additional substances, heavy metals), at the Ebro, Júcar and Northern river basins. Likewise, it has done further work on the analysis of organic micro-pollutants in the Júcar and Northern river basins, as part of the tasks for monitoring the quality network of underground water.

The company Ground Engineering Operations commissioned the Centro the analysis of sewage water generated by the polymer treatment used in special foundations.

The Water Quality Laboratory has collaborated with the Laboratorio de Hidráulica on experimental research for the hydraulic design of fishways. This collaboration has consisted of the analysis of various parameters related to the conditions of water for fish life.

Within the **Water Resources Division,** the work for the compilation and analysis of the data from gauging stations, reservoirs, canals and evaporimetres for the hydrologic year 2006/07 has been completed. This data is provided by the different River Authorities and has been included in the HIDRO database. The corresponding yearbook of gauge records has thus been published, both on paper and in digital format. The online yearbook has been improved to allow searching for canals and evaporimetres. The HIDRO database has also been updated to include the information about solids in suspension in rivers, making it accessible online as well. Furthermore, has been completed the analysis of correlation between gauging data from the Sistema Automático de Información Hidrológica (SAIH, Automatic System for Hydrologic Data) and the Red Oficial de Estaciones de Aforos (ROEA, Official Network of Gauging Stations). Advice has been provided to the DGA on the positioning of new gauging stations according to hydrologic uncertainty criteria, as well as on devising a new basic network including the most important stations of the ROEA. The study of the extrapolation of the rating curves to high levels of water has been started, as well as the quality analysis of the gauging data registered at the stations.

A new assessment of water resources in a natural regime has been completed. It covers the period 1940/2005 and has been performed applying the model SIMPA (Sistema Integrado de Modelización Precipitación Aportación–Integrated System for Rainfall Runoff Modelling), developed by the Centro de Estudios Hidrográficos. This new assessment has benefitted from the improvement of the procedures for the interpolation of rainfall and temperature, as well as improvements in the calculation of potential evapotranspiration. Furthermore, the model has been adapted to the new groundwater bodies. As a result, a set of maps to be used for the Plans for river basins, showing the monthly distributed values of rainfall, potential and actual evapotranspiration, recharge and superficial, groundwater and total runoff, have been obtained. Furthermore, those maps has been periodically updated to be used for preparing the reports on hydrological conditions of the river basins prepared by the DGA. In connection to the model SIMPA, further work has been done on the implementation of distributed models to enable a more accurate calculation of the groundwater flow.

Regarding droughts, the Division has, as in previous years, collaborated with the DGA on the drafting of the quarterly and annual reports on the hydrological conditions of the river basins. This collaboration has comprised the development of hydrological indicators from the information sent periodically from the River Authorities. Besides, the work for the application of dendrochronology to the study of historic droughts has been completed, a work carried out in conjunction with the Universidad de Castilla-La Mancha.

The work on the assessment of climate change impact on water resources in a natural regime of Spain has been completed. This work has required the use of data provided by the Agencia Estatal de Meteorología (AEMet, Spanish Meteorology Agency) on the rainfall and temperature projections for the 21st century, obtained from the results of a set of general circulation models, which were then locally adjusted. Thanks to the treatment of the projections and their later incorporation into the model SIMPA, a set of projections for different variables of the hydrologic cycle have been obtained. This has enabled the analysis of impact on water resources. Furthermore, an initial approximation to climate change impact on extreme events, floods and droughts has been tackled.

In the subject of floods, the Division has developed throughout 2009 the maps of flood peaks discharges in a natural regime for all the inter-communitarian

river basins. Likewise, the computer application, initially created only for the basin of the river Tajo, was extended to enable the display and consultation of the maps of the rest of the basins. The Conference for launch of the maximum discharge map of the river Tajo basin took place in May. The opportunity was taken for the explanation and distributing of the maps.

A further task completed by the Centro was the drafting of a proposal for the methodology to be applied in the calculation of the design hydrographs for designing the spillways for dams. Some of the methodological aspects included in the proposal have been developed in conjunction with the UPM. Besides, the Division has done further work on the planning and management of flood zones and has participated in the Grupo de Trabajo Nacional de Inundaciones (Spanish National Working Group on Floods). One of the most important tasks carried out as part of this Group was the collaboration on the drafting of the Guía metodológica sobre Evaluación Preliminar del Riesgo de Inundación (Guide for Preliminary of Flood Risk Assessment). This guide falls within the process for the implementation of the Directive 2007/60/CE, regarding the assessment and management of flood risk, and within the development of the Sistema Nacional de Cartografía de Zonas Inundables (SNCZI, National System for Cartography of Flood Prone Areas).

Throughout 2009, the Division has provided support to the Dirección General de Carreteras (DGC, General Directorate of Roads) on updating the contents of the chapter about the calculation of design flows in the Instrucción 5.2 IC de Drenaje Superficial (Code 5.2 IC for Surface Drainage), an activity carried out as part of the process for revising the said Code, currently undertaken by the DGC.

The Water Technology Division has provided support to the DGA on different interventions.

As far as Plan Nacional de Reutilización (National Plan for Reuse) is concerned, the Water Technology Division has coordinated, as done in the past, the working group on Water Technology and it has completed the study on the reliability and efficiency of regeneration technologies and associated cost. Furthermore, it has provided technical assistance in the development of the Manual about good practice in the reuse of regenerated water. Likewise, the revision and update of the database of the Spanish reuse systems has been started. This work will focus both on the digital structure and on the development of appropriate tools to enable its update online, as well as on the contents.

Regarding the process for wastewater treatment, the Division has carried out a study of the action of membrane bioreactors, aimed to learn more about their efficiency and limitations from the experience gained in the first installations built in Spain. It has also carried out a study of the water regenerating stations using rotating filters for the reuse of purified water in the Western Costa del Sol.

In issues related to wastewater treatment in small towns, the Division has completed the study of R&D&i proposals and is drafting, in conjunction with the Centro de Nuevas Tecnologías del Agua (CENTA, Centre for New Water Technologies) a manual for the implementation of treatment systems in small towns.

In the field of sludge treatment, the Division has carried out a preliminary study of the processes for reducing the amount and improving the quality of sludge in wastewater treatment plants. Likewise, it has begun a specific study about the use of ultrasounds as a pre-treatment for the anaerobic digestion of sludge.

As far as the implementation of specific interventions is concerned, a study on wastewater treatment in the city of Toledo has been carried out. This study contains the assessment of existing infrastructure, a series of solutions proposed for water treatment in this city and the preliminary design of a new plant. The process includes the biological riddance of nitrogen and phosphorus, and mud fermentation for the production of easily biodegradable organic matter. Furthermore, the Division has assessed the operation tests of the water treatment plants at Benalmádena and Fuengirola in Málaga, and Abejar, Covaleda, Duruelo and Vinuesa in Soria.

Regarding desalination, further work has been done coordinating the construction works for four desalination plants for the MARM in the Balearic Islands: Bay of Alcudia and Adratx in Majorca, Ciutadella in Menorca and Santa Eulalia del Río in Ibiza. Besides, the Division has continued providing technical assistance for the construction of the desalination plants of Melilla and Ceuta. Likewise, it has collaborated further with the Authorities of Canales del Taibilla on the desalination plans of Alicante II and San Pedro del Pinatar (Murcia).

THE EVOLUTION OF WASTEWATER TREATMENT IN SPAIN

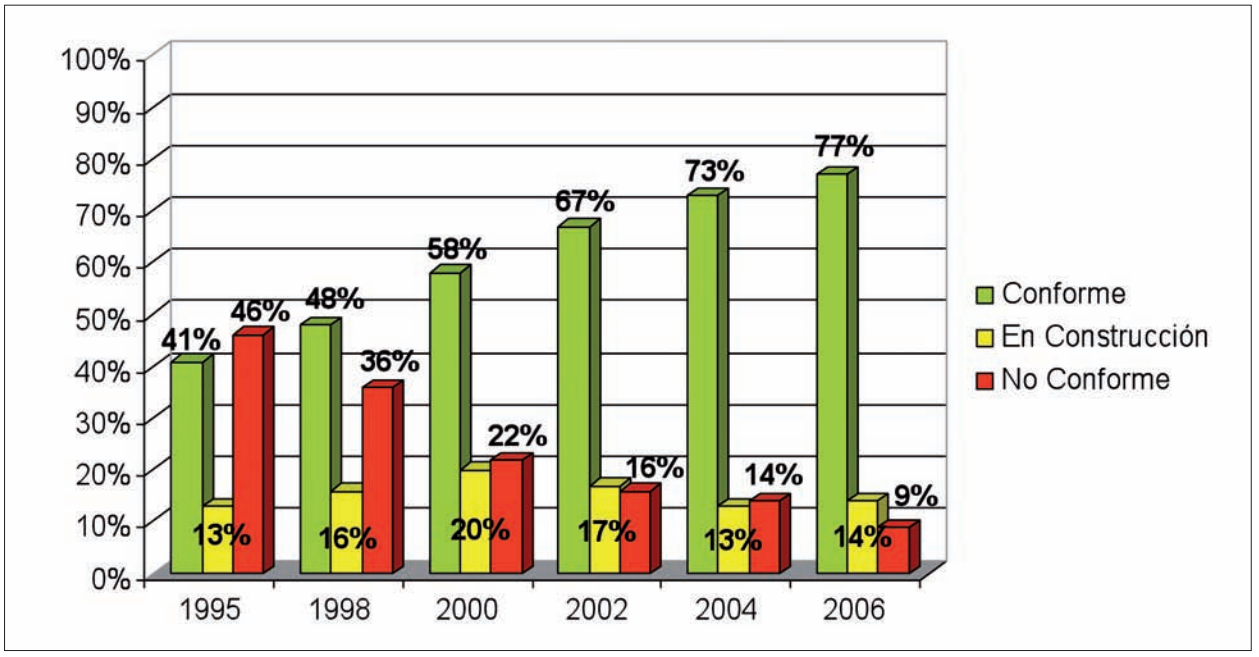
Remarkable progress has been achieved over the last few decades in Spain in the area of urban wastewater treatment. The CEDEX has been present providing support to the various government administrations involved.

In a country undergoing the development of its infrastructures, primary needs are covered first. These include water supply in appropriate amount and quality. Thus, in relation to water treatment, the areas that first developed in Spain were water purification and, in the case of Canarias, water desalination. Sanitation and wastewater treatment were perceived merely as measures to minimise health risks. Cities progressively build sewage systems, although wastewater is still directly discharged into rivers or into the sea without any previous treatment. Back in this time, both social conscience and legislation about environmental protection were scarce.

The first intervention plans were developed in places where sewage posed a risk to human health or for some other use of water. Sanitation and water treatment interventions in Spain arose during the 1970s thanks to the Partial Plans devised for certain tourist areas of the Spanish coast (Costa Brava and Baleares). These plans tried to preserve and promote flourishing tourism, and thus prevent foreign press from questioning the healthiness of these destinations. The CEDEX provided technical assistance in these initial times, and even sent its technical staff temporarily to the regions in question.

Autonomic plans appeared in the 1980s, devoted to solving the problems generated by the enlarged urban settlements, such as Madrid, Comunidad Valenciana or Cataluña. The large treatment plants were undertaken in phases. It was in fact very common that only primary treatments were implemented initially. The biological processes consisted on basic designs of trickling filters and activated sludge with no further objective than that of reducing solids and organic matter. The CEDEX collaborated with some Autonomous Communities in the development of these plans.

Technical knowledge was scarce back then. There were few construction works and few specialised companies, who had to maintain qualified technical teams. Many of these infrastructures were financed and constructed by the central government. During these initial stages, the CEDEX played a very important role on the establishment of communal technical criteria. It was the entity in charge of assessing the concourse for the construction of infrastructure and it set the technical bases for the standardization of projects on this subject. The CEDEX coordinated the government administrations and participating companies, it drafted a Model for specifications of technical bases for the concourse for the design and construction of water treatment plants. This model compiles most of the knowledge available at the time regarding the design of these installations and it was used as a reference until the 1990s by



Evolution of compliance with Directive 91/271.

many government administrations in a large number of construction concourses.

As could be expected, there were some failures among the first constructed infrastructures, both in design and in operation. The scarce technical and material resources, as well as the limited environmental conscience, contributed to these failures. Local administrations receiving the infrastructure, in some cases, lacked resources for, and interest in their exploitation.

In the mid 1980s, when Spain joined the European Economic Community and in parallel with economic growth, social conscience becomes more pro-conservation, while environmental legislation, mostly coming from the European institutions, becomes abundant.

Since the approval in 1991 of the Directive 91/271/CEE about treatment of urban wastewater, the situation of sanitation and water infrastructures in Spain, and, in general, the whole of the European Union, has undergone a remarkable evolution.

The estimate of polluting charge to be treated under the framework of this directive (more than 73 million equivalent-habitants and only 41% compliance), shows the large investment that had to be undertaken and the large impact of tourism and seasonal population.

Aerial view of the Palma I wastewater treatment plant.

The Plan Nacional de Saneamiento y Depuración de Aguas Residuales (National Plan for Sanitation and Wastewater Treatment), implemented in 1995, together with the plans undertaken by the different Autonomous Communities have turned the original situation around. At present, compliance has reached 77%. An additional aspect to be taken into consideration is the fact that a third of the equivalent population discharges onto sensitive areas, so that nutrients must be eliminated in the treatment. No other European country has made a comparable effort.

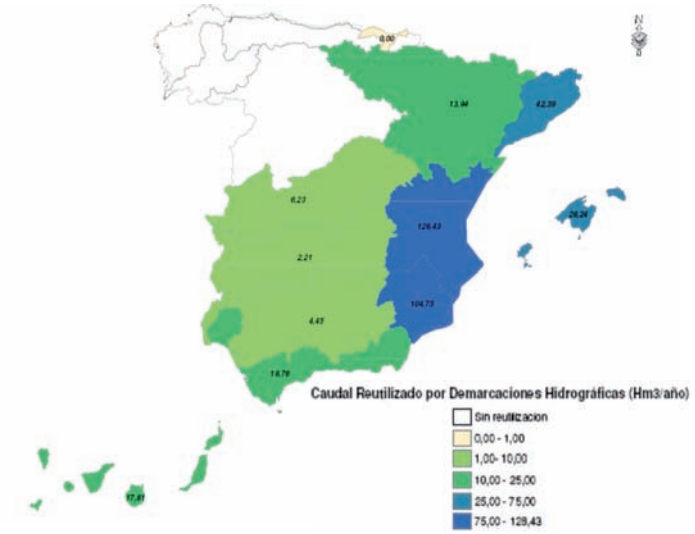
It is worth pointing out that, during the years the Plan has been implemented, design has become more and more conservative and the quality of the construction and of the equipment has been better. Furthermore, this investment has been accompanied by a better exploitation of the infrastructure. The proliferation of supra-municipal entities for the management of the water cycle (associations of local governments, consortiums, autonomic sanitation entities, etc.) has secured the success and the continuous exploitation of the infrastructure built in smaller towns.

This development has generated a similar growth in the professional sector connected to these activities (managing entities, contractors, engineering consultancies and research groups). From today's perspective, the starting point is notorious for the lack of knowledge and small number of qualified professionals. Nowadays, there are a large number of research groups; new technologies appear constantly; discussion forums are frequently organised; and the different entities have well sourced professional teams.

The CEDEX has participated along the whole process, providing support to different government administrations and, in particular, the DGA. The assistance provided has been very varied and has progressively adapted to the specific needs of the time, eliminating the activities that the government administrations and the private sector presumed were necessary.

As far as the construction of infrastructures is concerned, the work of the CEDEX has grown, from the study of design projects and solutions, to the assessment of operational tests and problem diagnosis for existing infrastructures.

The scarcity of water resources in many Spanish regions has meant that, in parallel to the development of water purification, wastewater reuse has also been tackled, in particular for agricultural irrigation. Given the importance of this activity in Spain, a normalization process has been required. This was carried out thanks to Royal Decree



Demarcaciones Hidrográficas	Caudal reutilizado (hm^3/año)
TAJO	6,23
GUADIANA	2,21
INTERNAS ANDALUCÍA	19,76
GUADALQUIVIR	4,45
SEGURA	104,75
JUCAR	128,43
EBRO	13,94
INTERNAS CATALUÑA	42,39
BALEARES	28,24
CANARIAS	17,80
TOTAL	368,2

Volume of reused water in 2006 in the different river water authorities.

1620/2007, from the 7th of December, which established the legal context for the reuse of treated wastewater. The CEDEX has given its support throughout the development of the decree, in fact a long process due to the complexity and repercussion of the various aspects of the law. This is one of the few codes on water issues that has not been imposed by the European Union.

It is worth mentioning the database of reuse systems in Spain, developed by the CEDEX. Thanks to this database it has been possible to carry out a diagnosis of the Plan Nacional de Reutilización (National Plan for Effluents Reuse).

Water treatment stations are required to provide a growing reliability. Quality regulations for the effluent are more and more strict each time. The riddance of nutrients, enforced for sensitive areas under the risk of eutrophication, and the reuse of wastewater are the two main conditioning factors that force the implementation of new, increasingly more sophisticated, treatments. The very active dynamics of the sector nowadays mean that new processes and technologies arise every day, both on water purification and regeneration. The most necessary job currently being developed by the CEDEX could perhaps be that of assessing the operation, performance and cost of emerging technologies as soon as they become an industrial reality. Thanks to this task, government administrations have at their disposal suitable knowledge for decision making. Thus how the different emerging process have been progressively assessed (oxidation ditches, two-stage treatment, sequencing batch, reactors, membrane bioreactors, etc.).

Within the area of water reuse, the different regeneration processes have been monitored from their origin. It is worth mentioning the participation in the DEREA project (Demostración en Reutilización de Aguas) developed in Gran Canary between 1995 and 1996. The project consisted of a pilot experimentation of the different water regeneration processes. Furthermore, Centro has also participated in the recent study about regeneration technologies to be applied according to the uses established on the Royal Decree 1620/2007 and the associated cost.

When purifying and regenerating wastewater, sludge is produced in the different processes of the treatment. This sludge is usually treated at the same plant to obtain its stabilization. The large development of water treatment infrastructure has brought an important production of sludge that needs treatment and evacuation. The Directive 86/278/CEE regulates the conditions the sludge needs to have in order to be applied to agricultural soil, limiting the content of heavy metal. The Plan Nacional de Lodos de Depuradoras de Aguas Residuales (2001-2006) was approved in June 2001. The main objective of this plan has been the improvement of the management and, in particular, the optimization of agricultural use. The production of sludge in 2006 was more than a million tons of dry matter, an increase of more than 55% since 1997.

Around 65% of the sludge produced was destined to agricultural uses and the level of heavy metal has been reduced thanks to controlling industrial discharge into the sewage system. The Consejo de Ministros (Spanish Cabinet) approved in December 2008 the Plan Nacional In-

Membrane bioreactor in the Illescas wastewater treatment plant (Toledo).

Anaerobic digestion pilot plants in the Tudela wastewater treatment plant (Navarra).

tegrado de Residuos (PNIR, National Integrated Waste Plan) 2008-2015, which will entail the revision of the Plan for Sludge. The PNIR evidences the lack of knowledge about the properties of sludge from different treatment processes. In order to support the revision of the Plan, the CEDEX has carried out an ambitious programme for the property definition of treatment plant sludge produced in Spain, in collaboration with various institutions, such as the Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario (IMIDRA, Madrid Institute for Rural, Agricultural and Alimentary Research and Development), the Centro de Espectrometría Atómica (Centre for Atomic Spectrometry) of the Faculty of Biological Science of the Universidad Complutense de Madrid (UCM) or the Grupo de Contaminantes Orgánicos Persistentes (Group for the study of Persistent Organic Polluters) of the Environmental Department of the CIEMAT. Furthermore, the CEDEX, in collaboration with NILSA, a public enterprise for the management of sanitation and water treatment in Navarra, has set up a research line based on experimentation of different stabilization processes in pilot plants, in order to establish common values for basic concepts, such as the stabilization or the disinfection of sludge.

For the implementation of these jobs that develop and structure knowledge, the CEDEX has growing support and collaboration from the managing bodies and, even, from private companies, as they all benefit from sharing knowledge. Therefore, it is increasingly frequent to channel this support through the Asociación Española de Abastecimientos de Agua y Saneamiento (AEAS, Spanish Association for Water Supply and Sanitation). Knowledge is then transferred to the water-treatment sector through broadcasting the different studies, as well as through the publication of manuals and good-practice guides.

Knowledge transfer is one of the key tasks of the CEDEX and, in relation to this, it is also worth recognising the support given to government administrations and to the sector in general on the education of specialists in the Course for treatment of wastewater and exploitation of treatment plants. This course holds an average number of eighty students and in 2009 it was held for the twenty seventh time.

This range of activities, which are carried out by the Centro de Estudios Hidrográficos, are complemented with the support provided by the Centro de Estudios de Puertos y Costas in relation to the channel systems for the discharge of wastewater into the sea, mainly on project revision, environmental design, methodology development for evaluating the impact of the discharges and solving local issues.

Currently, the new "National Plan for Water Quality: sanitation and wastewater treatment 2007-2015" is underway, which will complete the construction of the systems required explicitly by Directive 91/271 and increases the number of interventions to include smaller towns in environmentally protected areas. Technology is continuously evolving in search of new processes that enable expanding existing installations, with the smaller possible cost and invading the smallest possible area, as well as the improvement of performance in the processes, both on the treatment of water and sludge. The CEDEX is developing a range of studies along this line. Furthermore, energy consumption, as in any other sector, is increasingly important and substantial progress is currently being achieved on energy control and optimization.

Alongside these aspects, in the short and mid-term, water treatment in small towns below 2000 population equivalents must be tackled as the main pending issue. This range of population may add up to a very small percentage of the total pollution, but it is crucial in terms of total number of treatment plants. In the following years, in order to reach the environmental objectives of the Water Framework Directive, wastewater treatment of thousands of towns must be tackled. Previous experiences have shown that, the smaller the town, the greater the risk of failure. Careful planning must therefore be developed, including a correct definition of towns and the provision of support to the local governments required in order that exploitation can be maintained. Supporting this future development, the CEDEX and the CENTA have collaborated on an analysis of the situation in Spain, they have identified the R&D&i needs and, finally, they have drafted a manual for the implementation of water treatment systems in small towns.

In the future, the situation will probably be conditioned by a further concentration of raw influent, motivated by the growing number of techniques for saving in urban water consumption. Greater quality will be required for treated water due to new environmental goals, water reuse, control of priority and polluting substances and the possible decrease of resources generated by climate change. However, the growing sophistication of treatments has an important secondary effect: the increase in energy consumption associated to these processes. The water sector has traditionally been responsible for energy production. However, nowadays, not only due to water treatment, but also to the various stages related to its use (collection, purification, desalination, improvement of irrigation efficiency), the sector is becoming a large consumer of energy. The big challenge will be the improvement of performance, minimising energy consumption.

Likewise, further attention ought to be given to stormwater runoff, its regulation and management in order to minimise the impact it currently has. In some cases, in spite of the large efforts, rainwater is preventing compliance with environmental objectives.

Regarding exploitation, besides improving the control to obtain the optimization of energy consumption, further work will be required to broaden the knowledge about generation and control of odour in sanitation and water treatment systems. Odours will have to be considered in the design phase of sanitation networks.

The CEDEX has the intention to carry on providing its support to this sector in these and other future needs, from the position it has occupied since the beginning, as an independent entity of large technical ability and enthusiasm, collecting experiences and enabling the regulation of knowledge on this issue.

CENTRO DE ESTUDIOS DE

PUERTOS Y COSTAS

The Centro de Estudios de Puertos y Costas is the unit of the CEDEX specialising in all aspects related to Ports, Coasts and Navigation. Therefore, it services society, first of all, by providing support to the different governing bodies with competences in these fields within the Ministerio de Fomento (Ministry of Transport) and Ministerio de Medio Ambiente y Medio Rural y Marino (MARM, Ministry of the Environment): Puertos del Estado (State Ports) and Dirección General de la Marina Mercante (DGMM, General Directorate of the Merchant Navy) in the first Ministry, and Dirección General de Sostenibilidad de la Costa y del Mar (DGSCM, General Directorate of Sustainability of the Coast and Sea) in the second.

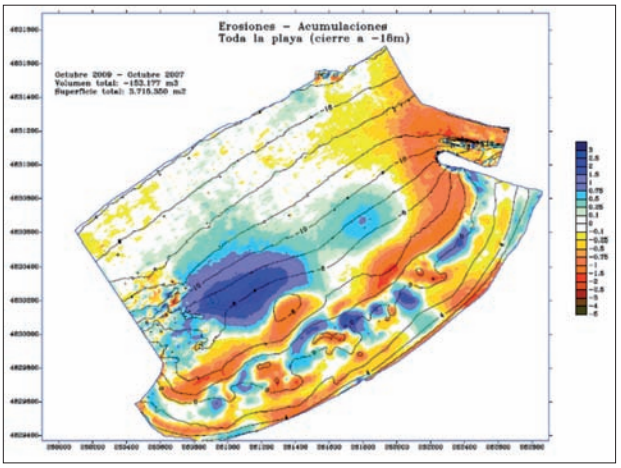
Throughout 2009, the work of the Centro has focused mainly in the framework of Acuerdos de Encomienda de Gestión (Management Commission Agreements) and other Conventions that define long term shared strategies for providing support services to enable the maintenance and development of lines of work that involve advanced research and experimentation in Ports, Coasts and Navigation. The goal of these lines of work is to provide answers to the current and emerging needs of Engineering and Environmental services within the dynamic, complex and demanding marine and coastal environment.

It must be emphasized, in the first place, the range of activities carried out for Puertos del Estado and the Sistema Portuario de Titularidad Estatal (State-owned Port System). Having completed the Agreement 2006-2008 between the CEDEX and Puertos del Estado in 2008, during 2009 work has been carried out, in accordance with the clauses of the Agreement, under the Framework of an annual extension, with an Annual Work Plan subscribed by the President of Puertos del Estado and the General Director of the CEDEX. This work has yielded 33 reports issued throughout the year that add to the 104 already issued during the regular period of the Agreement, 2006-2008.

Two thirds of the activities are destined to meet demands for specific studies received directly from the National Port Authorities, prioritized by Puertos del Estado. Throughout 2009, the Centro has worked on 34 commissions for 19 different Port Authorities, of which 17 have already been completed. The other 17 commissions will extend onto 2010, together with other jobs that have already been planned, should they be confirmed, and new jobs that may arise. In spite of the special dedication to the ports of Bilbao, Gijón, Las Palmas, Cádiz, Valencia and Barcelona, a tendency towards a more balanced distribution of the work is implemented. Such tendency was initiated in 2008 after the heavy concentration of work in earlier years on the new large infrastructures under development in the ports of Coruña, Gijón, Valencia and Barcelona.

The Centro has carried out studies of maritime climate, wave propagation and disturbance in the ports of Pasajes (re-analysis of the extreme conditions for the study of the defence structures of the outer Port), port of Bilbao (transformation coefficients for wave characteristics in the Port and study of the disturbance at the extension basin for the final configuration of the wharfs), Ferrol (comparison of disturbance predictions at the outer basin with actual measurements), Tenerife (study of tidal profiles in the port), Las Palmas (extreme wave conditions for the construction of the defence structure for the basin of la Esfinge and numerical study of the disturbance), Alicante(disturbance measurements for the analysis of the outer basin) and

Testing of the head of Punta Lucero (port of Bilbao) in the CEDEX's Multidirectional Wave Tank.



LEFT
Evolution of the beach of Salinas and harbour mouth in Aviles, period 2007-2009.

RIGHT
Test of the connection between the vertical and sloped sections of the basin of La Esfinge, port of Las Palmas.

Tarragona (study of alternatives for a new outer basin).

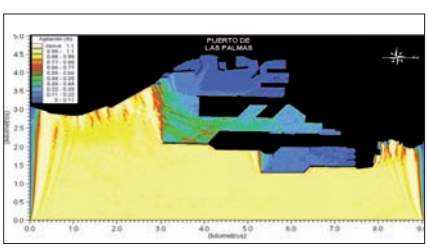
Likewise, work has been carried out on the field of ship manoeuvres in the ports of Bilbao (cruise ships at the outer berth of the Abra), Gijón (access to the new basin, in collaboration with SASEMAR), Marín (commercial wharfs), Las Palmas (safety in the access to the new basin of la Esfinge), Algeciras (access in Tarifa port considering the new infrastructure), Castellón (manoeuvres at the Southern basin), Barcelona (National basin) and Baleares-Mahón (operational limits and towing ship characteristics).

Small-scale three-dimensional physical models have been used in experimental studies for the layout design of ports for Las Palmas (basin of La Esfinge), Cádiz (new container ship terminal) and Valencia (extension of the port of Sagunto).

The stability and functionality studies of port structures using reduced-scale models carried out in the year 2009 have been for the ports of Bilbao (breakwater head of Punta Lucero), Coruña (different construction options for the basin of Punta Langosteira), dike at the basin of La Esfinge (connection between vertical and sloped sections), Málaga (overflows at the defence dike), Valencia (dike in the port extension and wave attenuation elements at the America's Cup basin) and Barcelona (redesign of the dike at the North harbour mouth for receiving cruise ships). The tests corresponding to the ports of Bilbao, Coruña, Valencia and Barcelona have been carried out in the CEDEX's multidirectional wave tank. This singular installation combines the highest possible level of realism in the reproduction of waves with 3D reproduction, particularly appropriate for the analysis of delicate points in a structure.

A number of studies of environmental issues and port dredged materials have been carried out under commissions from the Port Authorities of Avilés (monitoring sediment patterns in the complex Salinas beach-harbour mouth), Villagarcía (environmental monitoring of the dredged materials at the port) and the study for the establishment of the means and resources required for fighting accidental pollution at the port of Huelva, finished during 2009. This work stands out due to the hydrodynamic complexity of the system comprising the mouths of the rivers Tinto and Odiel and due to its particular environmental value. As a result, a large number of accidental situations and spills of different products have had to be considered and evaluated, as well as maritime and atmospheric weather conditions (waves, wind, tides) and optimum guidelines for action in each case.

Numerical study of the disturbance at the basin of La Esfinge, port of Las Palmas.

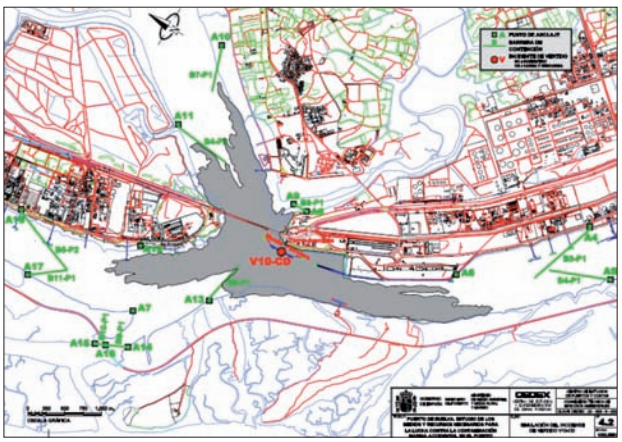


It is worth mentioning the large number of collaboration commissions received from the Port Authorities, to be met in 2010. This will require a special effort on behalf of the CEDEX. As particularly relevant issues in the immediate future, the following must be pointed out: activities related to risk in maritime operations –linked to ship manoeuvre

studies- and activities related to environmental risk management, such as is the case of the latter cited study. In relation to ship manoeuvre studies, it is worth noting the provision by SASEMAR of a simulation installation compatible with that of the CEDEX, which will enable the optimization of the use of these technological resources owned by the Ministerio de Fomento.

A significant part of the Agreement is focused on methodological and innovation works of general interest for the port system. This collection of activities, the development of which often runs during various years, has undergone a lower level of activity this year due to the Agreement being under the condition of an extension. Even so, a good number of new activities have been defined in all four agreed lines of work, to be developed during the coming years. These lines of work are Physical Environment and Infrastructures, Geotechnics for Maritime Works (developed by the Laboratorio de Geotecnia of the CEDEX), Environment and Risk and Transport (developed by the Centro de Estudios del Transporte of the CEDEX). Among the activities completed by or under development in the CEPYC, it is worth mentioning the probabilistic studies of structural reliability, the modelling of the interaction between waves and sheltering structures, forces and overtopping in breakwater crown walls, an alternative methodology for determining quay operational state as a function of meteorological conditions, parametric description of persistence events and estimate of extreme directional wave regimes, and implementation of a forecasting system for the port of Valencia, in collaboration with Puertos del Estado.

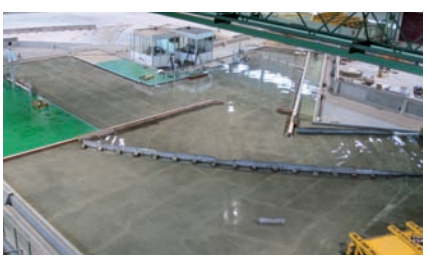
Regarding environmental issues, the Centro has completed the studies on the use of bio-tests for the environmental characterization of dredged materials in ports and the support activities for compliance with the Water Framework Directive (contribution of the ports to the Instrucción de Planificación Hidrológica –Water Planning Code-). Further work has also been done providing support in the drafting of new recommendations for dredged material management. Likewise, a viability study for a metric of benthonic macro-invertebrates in port and coastal water has been started.



TOP
Simulation of an accidental spill in the ria of Huelva. Barrier location.

BOTTOM
Model of the new container-ship terminal in the port of Cádiz.

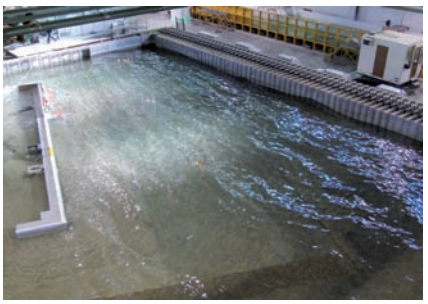
In the scope of the Ministerio de Fomento, during 2009, the work for the DGMM under the Agreement 2008-2010 has been further developed. A total of 28 final and/or progress reports have been issued throughout the year, and are to be added to the 17 reports previously issued. The agreement is structured in eight lines of action. In the first line of action, the CEDEX provides support to the activities of the International Conventions endorsed by Spain in the IMO (International Maritime Organization), as well as OSPAR, Barcelona, Bonn and EU organisms with competence in these fields. In the second, work is also being carried out on the regulations for the endorsement of products to be used in the fight against pol-



LEFT
Installation of disturbance monitoring equipment in the port of Alicante.

RIGHT
Simultaneous study of moored ships in the extension to the port of Sagunto.

LEFT
Overflow study of the dyke at the north mouth of the port of Barcelona.



RIGHT
Manoeuvres simulation at the port of Aviles.

LEFT
Equipment for bio-tests using luminescent bacteria.

RIGHT
Monitoring of the beach of Salinas.

lution, including support to the evaluation of specific products . In the third place, the Centro advises on the endorsement of decisions concerning the use of dispersants, thanks to the development of maps and laboratory tests for the analysis of the toxicity of these products. In relation to these activities, it is worth pointing out the development of the new Marime Pollution Fighting Laboratory in the Centro. The project of this new laboratory was completed in 2009 and it is expected to start functioning in 2010.

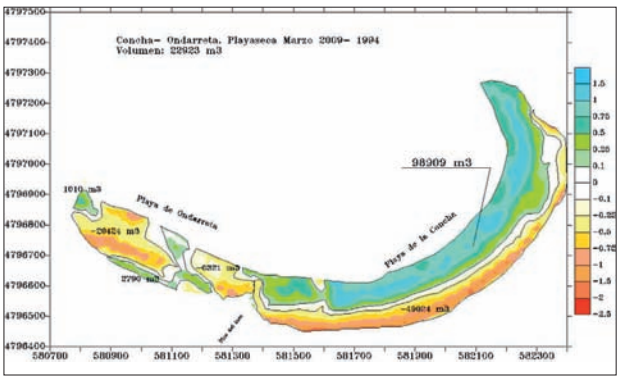
A particularly important aspect of the collaboration with the DGMM comprises the analyses for identifying the responsible parties in events of oil spills from ships. Eight reports have already been issued on eight different incidents.

The fifth line of action refers to the studies of Maritime Climate in relationship with navigation safety and has been subject to a noticeable level of activity, both in the analysis of climate incidence in recent accidents (11 studies have been issued), as well as on the compilation of historic situations in the course of accidents, a task that has been completed in 2009. Regarding ship manoeuvres in outer port zones, a study of anchoring conditions in the Bay of Algeciras has been finished and similar actions are currently underway for sensitive areas such as Bilbao or the area to the East of the Bay of Algeciras.

In relation to the use of places of refuge for ships in need of assistance, further work has been done on the database and geographical, environmental, economic and social information system for assistance in decision making. There is already a fairly developed prototype accessible through internet protocols that will be implemented in the General Directorate. Likewise, through a permanent technical support convention on environmental issues, the Centro has provided answers to one-off enquiries. It is worth mentioning one of these enquiries regarding a new procedure for cleaning ship hulls and its environmental effects.

In the field of the MARM, the activities carried out for the DGSCM must be mentioned in the first place. The Management Commission Agreement established in 2007 was concluded in 2009. Steps have already been taken towards the technical description of the fields of work and specific jobs to be developed from 2010 onwards, as the collaboration of the CEDEX with this General Directorate.

Real-time simulation of manoeuvres for entering the port in calm conditions, mooring at the pier and assistance by the towing ship.



LEFT
Beach of la Mamola. Turbidity during the maritime construction works.

RIGHT
Erosions / Accumulations on the beaches of the Bay of la Concha, San Sebastian.

Besides the provision, data treatment and revision of documents for the drawing up of a Plan for the Sustainable Management of the Coast, it is worth noticing the work done in collaboration with the International Conventions for the Protection of the Marine Environment in the field of competence of the DGSCM. Work has been carried out in different working groups and committees fostered by the OSPAR Convention: Biodiversity Committee (BDC), Eutrophication Committee (EUC) and Environmental Impact of Human Activities (EIHA), collaborating at the same time on the drawing up of the corresponding reports and national inventories required.

The support to the implementation process for the European Directives in coastal issues has benefitted from a special dedication, in particular for the issues of the Water Framework Directive regarding coastal and transition waters, in parallel to the work developed by the CEDEX's CEH for the General Directorate of Water. Likewise, the Centro has worked on the initial phase of the evaluation of coastal areas under the risk of flooding, related to Directive 2007/60/CE, and in the preparation of the Spanish Maritime Strategy in agreement with the regulations of Directive 2008/57/CE.

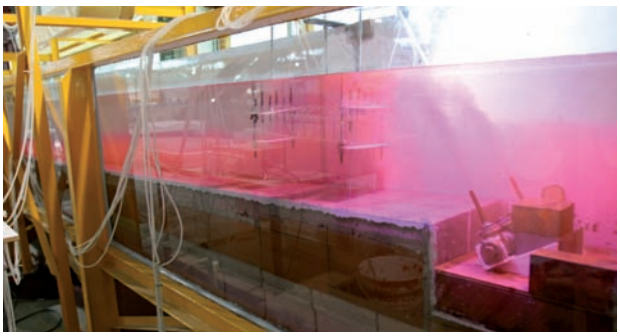
In the sphere of methodological and innovation activities regarding the interventions of the General Directorate, it is worth mentioning in the first place the development of a broad experimental research programme, which is the subject of the monograph accompanying this report. Furthermore, the Centro has worked on the reuse of reservoir sediments for restoring the sediment flux to the coast, on the field research of sediments in suspension in particularly complex areas, on the study of beach profiles, on the impact of wind energy installations away from the coast and on the wave runup on beaches.

Among the studies directly applied to the design and environmental evaluation of interventions, it is worth mentioning those oncoastal dynamics in Bogatell, Carabuxeira, Alcabre, Estrenc and Sabanell, on reduced-scale, mobile-base model tests of the Beaches of Puerto Naos and Santa Cruz de la Palma, as well as the 3D tests corresponding to their defence structures. It must be pointed out here the need, recorded initially in 2008, for a special effort on the broader use of experimentation to support interventions on the coast, both from the methodological and applied perspective. Other studies have included the possibilities of developing installations for surfing practice in Gran Canaria and the study of environmental issues related to the tidal basin of the river Guadalquivir, sand pollution in the area of the river Miño and in the beach of Mazagón, beach of Arealonga and river Urumea.

The nature of the interventions on the coast makes monitoring necessary as a procedure to feed design processes. Out of the activities carried out during 2009 in this field, it is worth mentioning those corresponding to Peníscola/Peñíscola, the Beach of San Sebastian including the Bay of La Concha, which suffered damages during the storm in March 2008, and the aforementioned study of the Beach of Salinas.

Finally, the Centro has also carried out work on the provision of applications and services accessible on the Internet for the DGSCM, as well as the on the dissemination of Spanish technology for coast related issues.

Still on the field of environmental issues, the Centro has carried out intensive work for the Direc-



TOP LEFT
Washing pool in area for storage of dredged material.

TOP RIGHT
Conference at the University of Hong Kong.

BOTTOM
Dilution tests on brine discharge.

ción General de Calidad y Evaluación Ambiental (DGCEA, General Directorate of Environmental Quality and Assessment) supporting the Statements related to the marine and coastal environment, as well as to liquid effluent spills in water masses, issuing 11 reports. For the Dirección General del Agua (DGA), the Centro has worked in particular on the impact of installations for discharge of by-products of water treatment and desalination plants into the marine environment. Furthermore, it is worth mentioning the sigining of an agreement with acuaMed for providing technical assistance to their work on desalination.

Among the R&D&i activities carried out throughout 2009, it is worth mentioning the participation of the Centro in two projects within the National Plan on the environmental effects of the discharge of desalination plant by-products. These projects focused on the efficiency of unconventional diffusive systems and on the environmental impact of the by-products. Likewise, the EOLIA project is worthy of mention, in development together with Acciona in the framework of the CENIT program.

Regarding the development of new abilities in the Centro, in 2009 a system for wind generation in the large-scale wave channel has been implemented. The first application of this system is underway in the aforementioned EOLIA project and will be directly applicable for a better evaluation of the effects of wave flowing over defence structures in ports and, therefore, for the functional aspects of these structures. As mentioned above, the end of 2009 has witnessed the completion of the new Marime Pollution Fighting Laboratory, as well as the start of the renovation of the multidirectional wave tank of the CEDEX after 18 years in service. This outstanding installation has been profusely used in the better study of most of the main marine works in Spain over the last two decades, such as Bilbao, Barcelona, Coruña, Gijón, Valencia, just to mention a few, as well as in the study of large beach conservation interventions. The new tank will have slightly larger working surface and draft in order to be used for three-dimensional models of bigger scale and will have improved systems for wave-generation and for control of test conditions.

The 10th Port and Coast Engineering Course has taken place in 2009. This year the course has been run in collaboration with the Universidad Politécnica de Madrid. The year 2010 will see a process aimed at analysing and considering how to modify the objective and contents of the course to achieve a better transfer of knowledge on these subjects to the professional group it is aimed at.
Finally, it is worth emphasizing the ongoing participation of the Centro in the international sphere, in particular through the Network of Institutes of similar characteristics in Europe and Latin America, as well as through international associations, such as IAHR and PIANC. Members of the Centro have participated as guest speakers in prestigious international forums, including the Breakwaters Congress in the United Kingdom, the Annual Meeting of the French Hydro-technical Association and the University of Hong Kong.

MONOGRAPHY: EXPERIMENTAL RESEARCH ON COAST DEFENCE

A large portion of the work carried out by the Laboratorio de Experimentación Marítima of the CEDEX's Centro de Estudios de Puertos y Costas during 2009 has been dedicated to experimental research on coastal defence. Among other work, it is worth mentioning two studies, the first one about the stability of submerged groynes, and the second about the influence of Posidonia oceanica meadow on the attenuation of waves on beaches, both developed within the framework of the 2007-2009 agreement with the DGSCM, under the chapter devoted to research for planning interventions.

STABILITY OF SUBMERGED GROYNES AGAINST VERY OBLIQUE WAVES

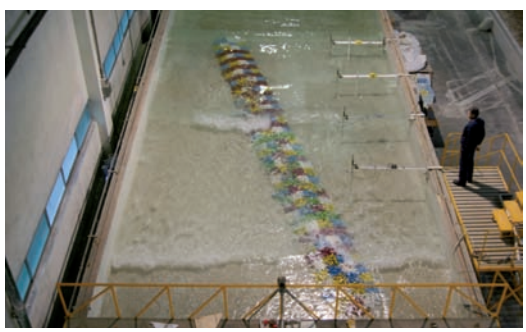
Groynes have historically been the most widely used elements for coastal defence. Their function is based on the blockage of part of the sediments carried parallel to the shore. Occasionally, this causes excessive accumulation of sediments upstream from the groyne, and the area downstream gets damaged as the erosion problems that ought to have been solved by the existence of the groyne move there. These effects could be controlled by lowering the top level of the groynes. This way, the sediment required for maintaining the profile of the beach is immobilized, while the rest of the material can go through to nearby areas. However, the application of this option of coastal defence has not yet been broadly implemented.

In order to contribute to the knowledge of this kind of structure and their future development along the Spanish coast, the DGSCM commissioned the CEDEX for the development of systematic reduced-scale model tests. The aim of these tests was to analyse the stability of groynes against waves, taking into account the main variables that appear in the process.

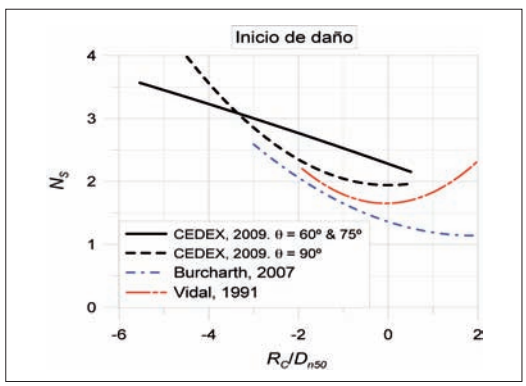
All of these tests have been carried out in a wave tank at the Laboratorio de Experimentación Marítima, in a scale of 1/20, modifying the parameters of the waves and the properties of the groyne so that the range of expected real conditions was covered. The groynes were erected in three different orientations, obtaining wave angles θ = 60°, 75° and 90° (with the latter angle the waves are perpendicular to the groyne, that is, the direction of influence is parallel to the structure). Figure 1 shows one of these tests with an angle θ = 75°.

Regarding the waves, two storms were generated with deep water wave steepness SO, p = 0,02 and 0,03, each comprised of 8 series of irregular waves with increasing significant wave height, up to HS,max = 5,0 m. As far as the structural parameters are concerned, the main variable has been taken to be the weight of the rock units. Two different weights were tested, W50 = 800 and 1500 kg. Furthermore, the influence of the thickness of the crest of the groyne has also been studied.

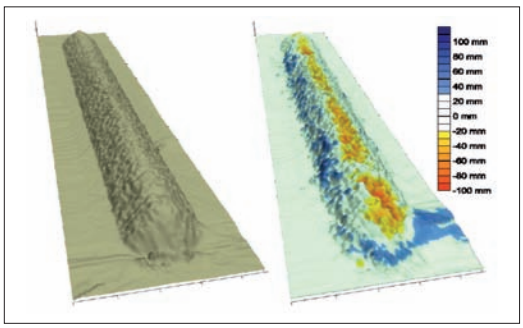
In order to define the initial stages of the damage, a photographic survey has been carried out. The objective was to determine the number of dam elements/pieces displaced from their original positions. The following graph shows the results obtained. The value of the stability number, NS, is defined as a function of the relative freeboard RC/DN50 and the angle, θ. To be able to compare with other similar structures, the graph includes the results obtained from two other research projects on the behaviour of detached breakwaters subject to non-oblique waves (θ = 0°, or waves parallel to the structure).



View of the tests in the wave tank (θ = 75°).



Stability of submerged/underwater groynes compared with that of detached breakwaters.



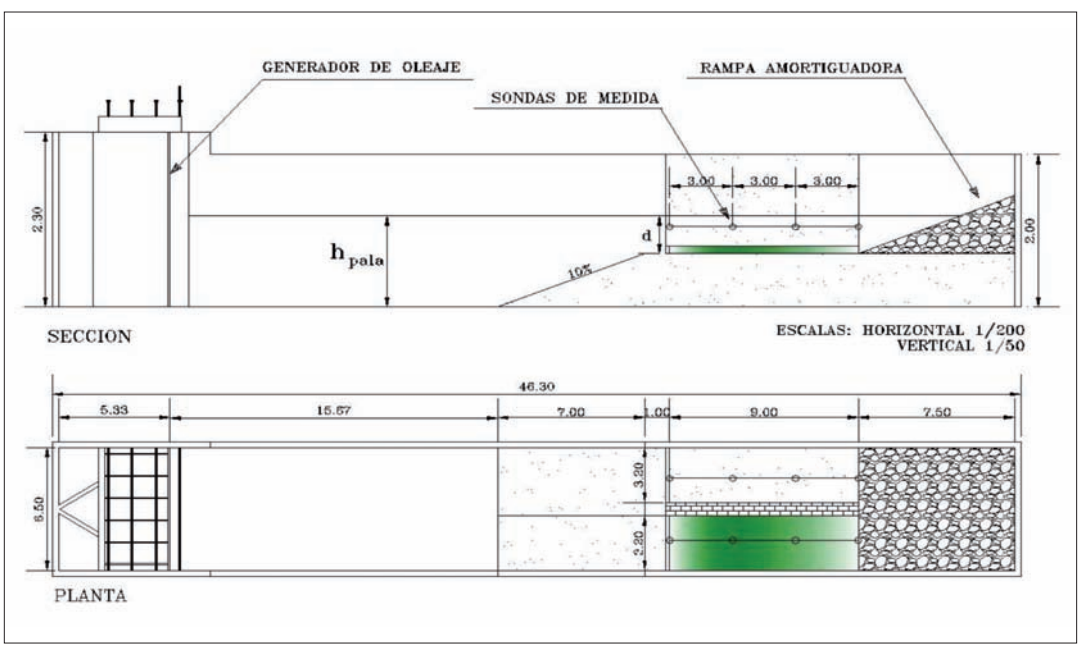
Topographic survey of the groyne (left) and eroded areas and zones of accumulation of material after the test (right).

For large deformations, the number of displaced elements is too high to be recorded using visual methods. Therefore, it is necessary to use other techniques to assess the damage based on the decrease in height of the groyne, or on the eroded cross-sectional area. This can be done by direct measurement of a number of sections along the structure. In the present case, however, a topographic survey of the complete structure has been carried out using a land LIDAR system which can generate a large-resolution digital model of the groyne, thus compiling much more detailed information than the aforementioned methods.

The outcome of the investigation confirms that, in general, submerged groynes are more stable than detached breakwaters. However, in opposition to the initial suppositions, stability decreases for waves with $\theta = 90°$, due to the symmetry of the waves breaking on the structure. Thus, for example, the weight required for a 1 m. submerged zone to withstand the storm with HS = 2.5 m. suffering no damage would be 560, 1200 and 2200 kg for waves at angles $\theta = 60°$ (and 75°), 90° and 0°, respectively.

WAVE ATTENUATION IN BEACHES WITH POSIDONIA OCEANICA MEADOWS

This research project, like the previous one, has been based on tests performed on small scale physical models of a Posidonia oceanica meadow. The said tests have been carried out in a wave tank in the Laboratorio de Experimentación Marítima of the CEDEX, on models to scale 1/10, modifying the parameters of the waves acting on the meadow (height, period and depth), in order to generate a range of average expected wave regimes. The test area has been divided into two equal zones. One of these areas was kept empty to serve as reference and control the attenuation caused by water friction against the side walls and the bottom. On both zones wave attenuation has been measured using eight probes distributed in two parallel groups of four.



Arrangement of the P. oceanica and position of the wave probes.

Worthy of mention is the special attention paid to the reproduction of the prototype, from the early phase of compilation of information about the characteristics of Posidonia oceanica, through material selection, to the final stage of the fabrication of the model. The key features of the recreated meadow have been the density, of 400 leaves / m^2, and the height of the plant, of 1 m. With respect to the material used, this has been selected watching that the floatation and stiffness requirements were met in order to guarantee a similarity in dragging forces and inertia between the model and the prototype. A total of 20 reels of thread for artificial grass, each 8000 m long, were used in the fabrication of the model. This thread has been fixed to 140 concrete slabs with dimensions 0.3 x 0.6 m, and cut in 10 cm strips. This process was done manually at the workshops of the CEPYC.

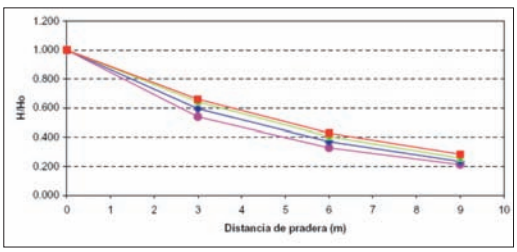
The tests have been carried out both under regular and irregular waves, with variable periods between 4 and 8 seconds, as well as for variable heights. In any case, breakage has been avoided. The maximum heights, therefore, were dependant on the depth. Three depths were tested: three, five and eight metres in the prototype. Under these conditions, the maximum wave height in the test was HS,max = 1.5 m.

Figure 6 represents the significant height wave variation throughout the meadow for the test with depth h = 0.30 m and period TP = 4.5 s. The attenuations obtained at the meadows during this test were some of the largest of all. The graph clearly shows the exponential shape of the curve, a result that was found in most of the tests and that has led to the consideration that attenuation can be properly defined by a single coefficient, called ki. The value of this coefficient has been found for each test and the curve of the variation of wave significant height has been adjusted to an exponential curve.

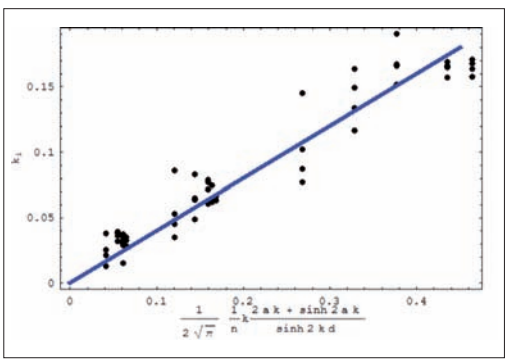
In order to estimate the value of the attenuation coefficient according to the characteristics of the waves, an elemental approximation can be used, that is, considering the variation of wave energy equal to the work performed by the wave induced drag force.

The following graph represents the relationship between wave characteristics (abscissas) and the attenuation coefficient (ordinates) for the tests under regular wave conditions. Also represented in the graph is the line of best fit, with a linear coefficient of 0.40 and a regression coefficient R2 = 0.915. In spite of the graph showing void areas and a substantial dispersion of the results, the relationship between the defined parameter and the attenuation coefficient is relatively clear. Furthermore, it must be taken into account that these tests refer to a unique specific density of leaves per unit surface, which has led the team to consider extending the study to situations with different meadow densities and heights, and to contrast the results with field word in order to obtain a much more precise idea of the phenomenon under investigation.

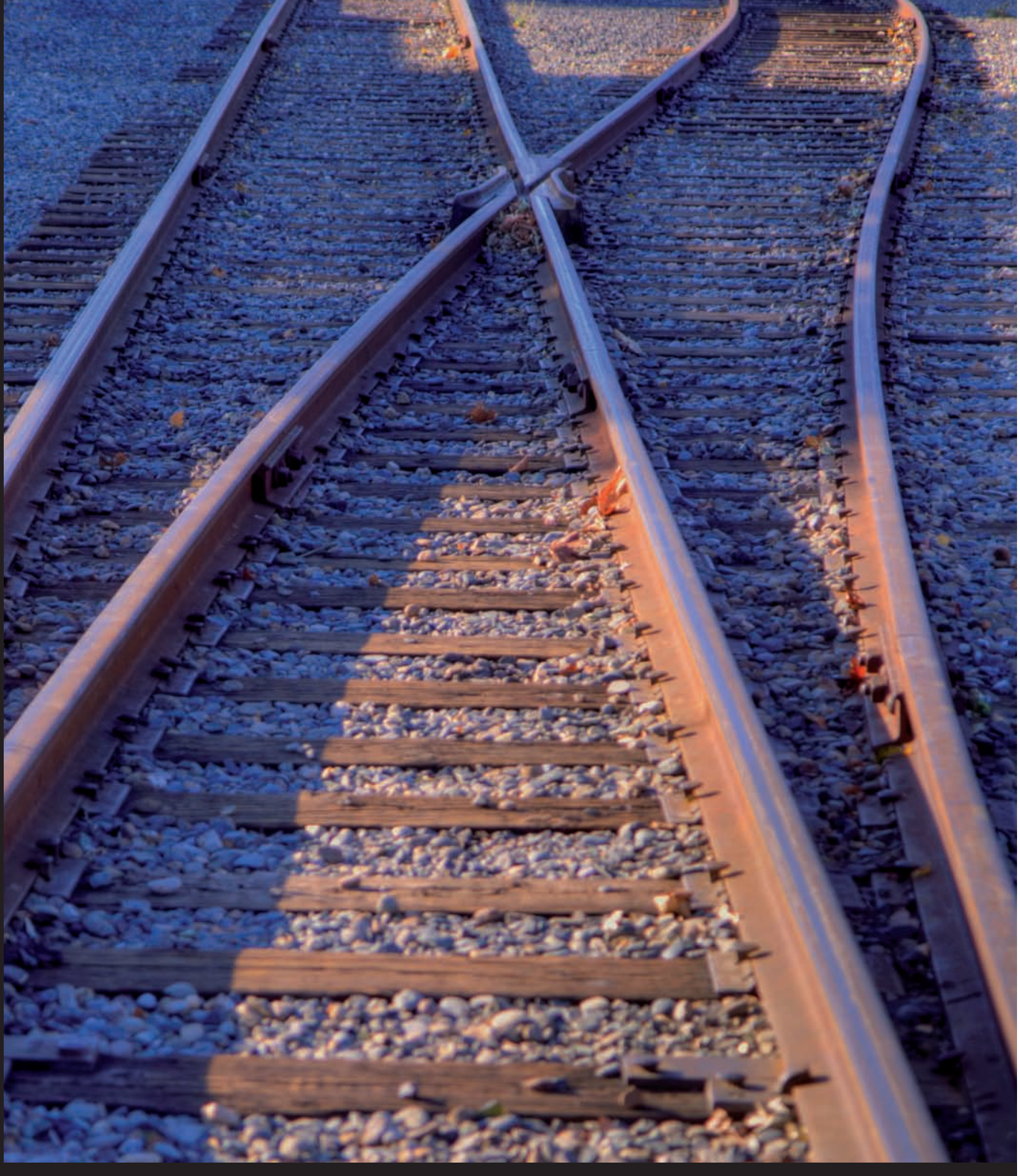
View of a 30 x 60 cm slab with threads of P. oceanica.



Attenuation throughout the meadow. Waves: irregular; h = 0.3 m; Tp = 4.5 s.



Attenuation throughout the meadow. Waves: irregular; h = 0.3 m; Tp = 4.5 s.



CENTRO DE ESTUDIOS DEL

TRANSPORTE

The Centro de Estudios del Transporte (Transport Research Centre) has concentrated its activities throughout 2009 on the field of roads and of transport in general.

ROADS

• Study of structural behaviour of pavements

The study of pavements as structures is one of the main research lines developed in this Centre. This entails aspects ranging from the definition of the materials' properties in the laboratory, through to the assessment of the behaviour of roads in use, including other relevant aspects such as the design of the pavement, laboratory deterioration tests or monitoring the structural response of roads subject to traffic loads. The Centro de Estudios del Transporte has a series of highly specialised testing facilities and equipment to carry out this work, which are managed by the Laboratorio de Infraestructura Viaria (LIV, Road Infrastructure Laboratory).

The Centre in particular has a Full-Scale Pavement Test Track, with world-wide unique features, a convenient installation for the assessment of structural behaviour of pavements. Over the last few years, this track has been used for the analysis of subgrades. A total of 3 tests, 18 sections, have been carried out for the Dirección General de Carreteras (DGC, General Directorate of Roads) of the Ministerio de Fomento (Ministry of Transport). The third test was completed in December 2009, having applied 1.3 million loads through the traffic-simulating vehicles. The research based on the results obtained in these tests is yielding relevant conclusions on the design and construction of subgrades.

Within this field of research, it is worth mentioning the technical assistance provided to the Ministry of Public Works of Algeria on the implementation of a full-scale test track in their country. This technical assistance –provided since 2008 and due to finish in 2010– has yielded important conclusions regarding the future programme for accelerated pavements testing in Algeria.
Within the research work carried out at the LIV on the design of pavements, it is worth pointing out the effort devoted over the last two years to the specific study of long-life pavements. This type of pavement, designed and maintained to last for 30 years and longer, represent nowadays an extremely interesting alternative, not only due to the evident impact on the quality of the circulation of users, but also because they entail a lower cost –both economic as well as environmental– throughout the long life cycle of the road, in comparison with equivalent pre-determined pavement usage life. Two outstanding interventions in this issue are:

- Participation in the Fénix Project "Research for Safer and More Sustainable Roads", financed by the Ministerio de Industria, Turismo y Comercio (Ministry of Industry, Tourism and Commerce) under the framework of the CENIT program.
- The development of an internal research project on the "Fatigue Endurance Limit of Asphalt Mixtures", started at the beginning of 2009 and due to finish at the beginning of 2010.

Worthy of mention within this same area of pavements design is the proposal for a code for design of pavements in tunnels, drafted for the DGC. This particular type of pavement was initially excluded from the scope of application of the design code of the Ministerio de Fomento, the regulation 6.1 IC.

It is also worth mentioning the increasing importance of the maintenance and rehabilitation of pavements as opposed to new construction, especially for the consolidated National Trunk Road Network. It is not strange, therefore, that new work focused on the study of the behaviour of pavements strengthening has begun for the DGC. During three years, it is expected to monitor a series of strengthened sections in mo-

torways. This will deepen the knowledge of the behaviour of this kind of layers from the structural point of view, a knowledge that is currently insufficient.

As well as the aforementioned work, it is worth mentioning the participation of the Centre in another CENIT project of the MInisterio de Industria, Turismo y Comercio, called OASIS ("Operation of Safe, Intelligent and Sustainable Motorways"). The main objective of this project is defining the motorway of the future, the operation of which will feature substantially higher levels of safety, user services and sustainability. The LIV collaborates in the definition of the methods and instruments to be used for the dynamic management of pavements, thanks to its broad experience in the field of instrumentation and modelling of road pavements.

A further pillar of the research on the design of pavements is represented by laboratory tests. This has enabled the drafting of regulations, as well as advising the DGC on definition and requirements of the materials' properties, as well as on the laboratory assessment of material behaviour. In this respect, it is worth mentioning the work carried out in relation to the use of asphalt mixtures with rubber dust obtained from used tyres. In particular, the Centre has commissioned the monitoring of a number of sections for testing this type of pavement, in order to evaluate the real possibilities for the application of the different techniques of rubber dust use in asphalt mixtures. The test sections have been built in the provinces of Ourense and Malaga during the months of April and May of 2009, on the N-532 and N-340 roads. Throughout the development of the construction work, the binders delivered to the plant were controlled, as were the bituminous mixtures. The control and monitoring of the different sections as built will be done over the following years through visual inspection, cores' testing, rolling noise measurement and deflexion measurement. This will enable the analysis of the structural properties and capacity of equivalent mixtures, made with and without rubber dust.

Construction/ Installation of an asphalt mixture made with rubber dust from used tyres on a test section in the province of Ourense.

The Centro de Estudios del Transporte has continued working on the study of possibilities for making use of other industrial by-products/subproducts on road pavements. In particular, these studies have focused on the use of steel electric furnace slag and the by-products from the incineration of urban waste. This work is promoted by the Dirección General de Calidad y Evaluación Ambiental (DGCEA, General Directorate of Environmental Quality and Assessment) of the MMAMRM, Ministry of Environment.

Part of this is the work started in 2008 on the technical and environmental definition of by-products from incineration of urban waste. The main objective of these studies is to evaluate the properties of this material and its possibilities as secondary aggregate in the construction of roads. The variables considered in these property-definition studies –besides the alteration of properties with time– are the influence of urban waste treatment prior to its incineration, the incineration technology itself and the treatment of the by-products. These processes determine the technical and environmental properties that open and close the possibilities of using these materials as part of road layers.

Within the field of laboratory tests, further work has been done on providing support to the Laboratorio de Geotecnia of the CEDEX for the property definition of aggregates for their use on the surface course of roads. Outside the road field, the Centre has provided support to the Laboratorio de Geotecnia on the study of bituminous mixes for the sub-ballast layer in railway lines. In relation to the latter work, 4 measuring campaigns have been carried out in 2009 with the instrumentation equipment placed in a test section in Valdestillas, on the high speed line Madrid-Valladolid; furthermore, a proposal for the technical specifications for the said material has been drafted.

• Auscultation of in-service pavements

A further key line of work of the Centro de Estudios del Transporte within the field of roads is the auscultation of in-service pavements.

The equipment of the Division of Pavement Auscultation and Management, in the one hand,

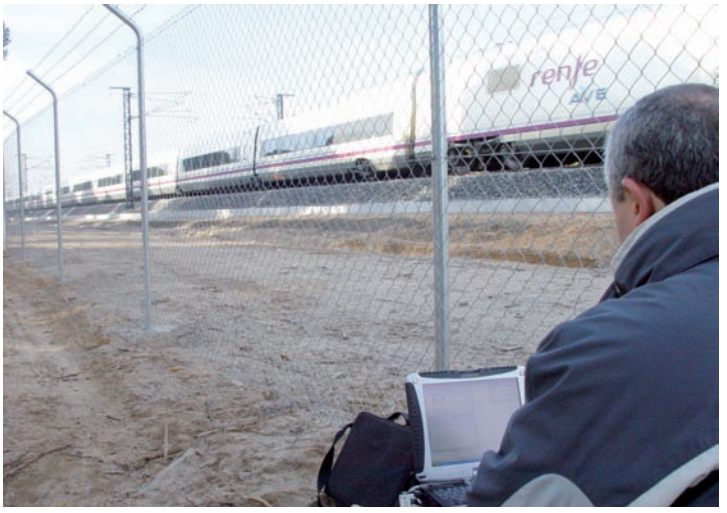
provides support to other research activities of the Centre, for example, in the fields of weight-in-motion and of monitoring of road pavements on the Full-Scale Pavement Test Track, or along the experimental pavement sections in service.

On the other hand, the auscultation equipment of the Centre is used for performing comparative tests between the measurements taken in Spain by auscultation equipment owned by different companies or institutions. Road administrations pay great attention to the condition of pavement surfaces, as this is closely related to user safety and comfort on the road. This motivates the frequent running of auscultation campaigns on roads under their management, the results of which contribute to the optimization of the large investment required for the maintenance and rehabilitation of the road network. A large variety of auscultation equipment is used in order to obtain these parameters, and it is therefore convenient to assure that the values obtained are sufficiently accurate, are harmonized and are independent from the measuring device used.

In 2009 the CEDEX has performed –in the interest of the DGC– two campaigns of comparative analysis, one of measurement of skid resistance taken using SCRIM and the other of measurements of longitudinal unevenness. The first describes the capacity of the rolling course to prevent skidding between the tyre and the pavement, whilst the second evaluates the differences between the theoretical surface and the built surface, which contributes to the comfort and safety of the road. The CEDEX has been in charge of the design, organisation and development of both of the campaigns, verifying the testing equipment, selecting the sections to be tested and performing the statistical comparative study.

The results obtained from these comparative assessment campaigns are useful both for the participating auscultation entities and for the administration responsible for the road network. The former have a test to calibrate their equipment and verify their correct functioning; the administration can verify and assure that the quality of the results delivered by the different equipment and entities is homogeneous and sufficient to be integrated into its management system.

A further road pavement property studied by the Centre is rolling noise. In 2009 the Centre has



TOP
Stock of by-products from waste incineration ready for sampling.

BOTTOM
Measurement taken using the instrumentation installed in the high-speed train test section with bituminous sub-ballast in Valdestillas.

set up a new line of research focused on the analysis of time evolution, as well as the analysis of the main factors the level of noise is dependent on for the same type of surface course. This is done using measurements obtained via the CPX method along a series of road sections of a number of Spanish provinces.

• Traffic and road safety

The work carried out throughout 2009 from the Division of Road Traffic and Safety has been focused in particular on the study of road safety in relation to road infrastructure and weight-in-motion. Likewise, this Division has provided assistance to the DGC in a number of specific issues of safety in in-service road tunnels.

As far as road safety in connection with infrastructure is concerned, it is worth mentioning the proposal for a practical manual for the inspection of road safety on in-service roads in Spain, developed for the Dirección General de Tráfico (DGT) of the Ministerio del Interior. The

Data collection using different SCRIM equipment in the proving of Cuenca in March 2009.

manual adapts the guide for road safety inspection of in-service roads of the National Trunk Road Network, developed by the CEDEX in 2008, for its application to roads under regional management. Special attention has been given to the aspects that need to be revised in connection to safety in secondary, low traffic roads, as these roads are generally the result of less demanding design and are provided with poorer safety equipment.

In the field of weight-in-motion, the Centre has continued in 2009 with the analysis of the best options for implementing a permanent weight-in-motion system on the national network. The analysis is based on the monitoring of three weight-in-motion fixed measuring systems, of piezo-electric type, installed on the A-5 motorway near Badajoz. During this year, the system has been calibrated, two tests have been carried out in order to verify its accuracy and, simultaneously and continuously, its operation has been monitored.

Regarding tunnel safety and equipment, the BIT application for the compilation of data on incidents in tunnels has been managed and maintained. This application was developed in 2008 for the DGC with the final aim of meeting the requirements established both by the Directive 2004/54/CE and by the Royal Decree 635/2006 about minimum safety requisites in tunnels of the National Trunk Road Network.

In the international sphere, the CEDEX continues to take part in the Technical Committee C.2, Safer Road Operations, of the World Road Association. The CEDEX is particularly active in the work related to the cost-benefit analysis of road safety measures.

• Participation in international projects and committees

It has been mentioned above that the Centro de Estudios del Transporte takes part in various CENIT projects of the Spanish R&D&i Plan in connection with road issues. Furthermore, some professionals at the Centre act as coordinators for a number of R&D&i projects connected to the Plan Estratégico de Infraestructuras y Transporte (PEIT, Strategic Plan for Infrastructure and Transport), in particular to those projects financed by the CEDEX in the years 2006 and 2007.

At a European scale, there are various lines of research under development in the Centre that are strengthened by its participation in European projects and committees. Worth mentioning are:

• Frequent participation in working groups of various CEN committees.

• Participation of the CEDEX as partner in the project DIRECT-MAT 'Dismantling and Recycling Techniques for Road Materials', part of the 7th European Framework Programme, or

• Collaboration with the ELLPAG Group "European Long-Life Pavement Group" and the FiWi "FEHRL Institutes WIM initiative" on weight-in-motion, both groups promoted by the FEHRL, Forum of European Highway Research Laboratories.

TRANSPORT PLANNING AND MANAGEMENT

The lines of work of the Centro de Estudios del Transporte in the area of transport are mainly centred on the monitoring and forecasting of transport in Spain and on the broadcasting and stimulation of good practice in the field of urban and metropolitan mobility and its coordination with long-distance mobility.

• Transport monitoring and forecasting

In the field of transport monitoring in Spain, the Centro de Estudios del Transporte has continued in 2009 with the analysis underway for Puertos del Estado (National Ports), of international freight transport chains that use Spanish ports. Once the detailed study of origins, destinations and routes related to the automation industry was completed half way through the year, work focused on the freight transport chains for the iron and steel industry.

Within this line of research, the CEDEX and Puertos del Estado have started developing a piece of software to simulate the hinterland for Spanish ports. This software aims to help identifying –for the import and export fluxes that use the different ports of national interest- the Spanish province of origin and destination of the freight,

for each type of freight and country of origin and destination. This is done by integrating the information currently available in the data bases of Puertos del Estado for port traffic with the information on international commerce in Spain from the Departamento de Aduanas e Impuestos Especiales (Department of Customs and Special Taxes) of the Agencia Tributaria (Spanish Tax Agency).

It is also worth mentioning that the CEDEX has edited a report on "El transporte en España" ("Transport in Spain") based on the Sistema de Indicadores de Seguimiento del Transporte y su Impacto Ambiental (SISTIA, System of Indicators for Monitoring Transport and its Environmental Impact), developed in previous years for the Dirección General de Planificación (DGP, General Directorate of Planning) of the Ministerio de Fomento.

• Good practice in the field of urban mobility and its combination with long-distance mobility

The Centro de Estudios del Transporte has continued participating during 2009 in the LINK project (The European Forum on Intermodal Passenger Travel) of the 6th Framework Programme of the EC. The objective of the LINK project is the setting up of a European Forum on Intermodal Passenger Travel to become the communication channel between authorities, associations, operators and user groups. This aims to promote better intermodal passenger transport as the key for a more efficient and integrated transport system to improve communications and minimise environmental impact. In this context, the CEDEX organised a seminar, held on the 19th of November, about the integration of information about transport services as a tool to serve passengers for planning door-to-door journeys.

Likewise, the Centre started participating half way through the year as a partner in the European project EPOMM-PLUS (European Platform on Mobility Management – Partners Learning Urban Sustainability). The main objectives of this project are the dissemination of good practice and advising national networks of experts in sustainable management of mobility.

In the field of the promotion of innovation in urban mobility –and as part of the tasks of EPOMM- the Centro de Estudios del Transporte has taken up again the database of good practice in sustainable urban mobility in Spain, developed in 2008 for the Secretaría de Estado de Infraestructuras y Planificación (National Secretariat of Infrastructures and Planning) of the Ministerio de Fomento, in order to update it.

Furthermore, the CEDEX completed at the end of 2009 the negotiation with the European Commission on the CLOSER project (Connecting Long and Short Distance Networks for Efficient Transport), included in the 7th Framework Program. The project is due to be developed throughout three years and will start in early 2010 under the coordination of the CEDEX and with the participation of other seven transport research institutes throughout Europe.

• Other research activities

The participation of the CEDEX in the ASSET project (Assessing Sensitiveness to Transport) concluded in 2009. This project pursued the development of methodological and scientific abilities for implementing European policies aimed for achieving the essential compatibility of protection of environmentally sensitive areas through the provision of an efficient transport system.

Other than the participation of the CEDEX in this and other European projects, it is worth mentioning the participation of the CEDEX in the transnational research programme "Road Owners Getting to Grips with Climate Change". This programme has been the result of the activities promoted by the ERA-NET Road. It has been driven by eleven European countries as a pioneering

Various teams participating in the data collection using different equipment for the comparison of measurements of longitudinal unevenness.

Data collection for the calibration of permanent weight-in-motion systems installed on the A-5 motorway.

experience for the transnational research on roads.

PARTICIPATION IN OTHER INTERNATIONAL PLATFORMS AND KNOWLEDGE NETWORKS

The work of the Centro de Estudios del Transporte is strengthened, eventually, through its participation in various platforms, knowledge networks, committees and working groups, both at the national and international level.

In the international context, the Centro de Estudios del Transporte has continued actively participating in 2009 in various international platforms. Besides the FEHRL, it is worth mentioning the ECTRI (European Conference of Transport Research Institutes).

The Centre has also contributed, through the participation of its experts, to the work of various international Committees of the AIPCR (World Road Association), of the North American TRB and of the CEDR (Conférence Européenne des Directeurs de Routes).

SUBGRADE TEST ON CEDEX FULL-SCALE PAVEMENT TESTING FACILITY

Accelerated pavement testing (APT) consists on the controlled application on pavement of a load simulating real traffic in order to assess the response of the said pavement to an accelerated process of damage accumulation. The track the CEDEX has in El Goloso, due to its outstanding characteristics, is one of the most powerful facilities of its kind worldwide. It enables the reproduction, in a relatively short space of time, of road wear suffered throughout the service life of the road. The programmed load application phase projected for the last test was completed in December 2009. This was the third test of a series focused on the study of subgrade performance, financed by the DGC.

The six sections under study represent different alternatives for the construction of high quality subgrades. Section 1, a reference section, is that of lowest load-bearing capacity. The other five sections represent an improvement on the reference section based on two independent techniques:

• The substitution of the capping layer by better-quality materials, in particular by in-situ cement stabilized soil (Sections 2 and 3).

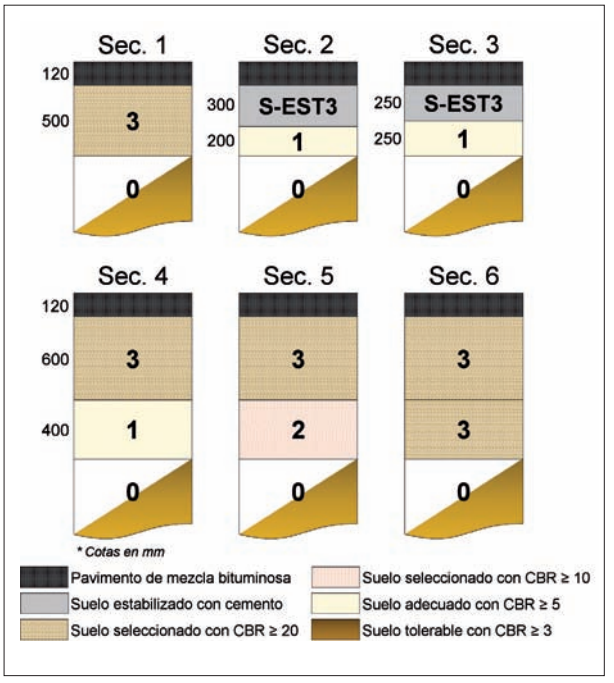
• The introduction of an intermediate-quality layer between the top layer –type 3 selected soil with CBR≥20– and the embankment of soil type 0 with CBR≥3.

The load applied by the two traffic-simulating vehicles of the track reproduces with great reliability the loading supported by pavements in use. In fact, the level of applied load, as well as the type of tyre, suspension system, transverse distribution, etc. are identical to those of lorries and trailers that drive on our roads.

Also in the pursuit of reproducing behaviour as close to in-service pavement as possible, the test has been carried out under the effects of sun irradiation and rain, generating a water table 1 metre below the top of the subgrades. Through more than two years, a total of 1,323,000 loads or vehicles have been applied.

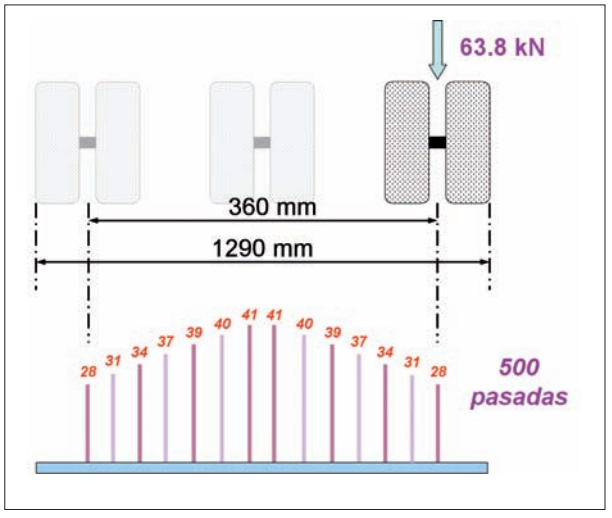
One of the main potential applications of the APT is the detailed knowledge of the performance of the tested section, that is, the evolution in time of the different distress mechanisms. In order to gain this knowledge, periodic auscultation of the subgrades is carried out to assess different aspects of the structural condition:

Full-Scale Pavement Test Track.



Tested sections.

Traffic-simulating vehicle.



Transverse distribution of traffic-simulating vehicle.

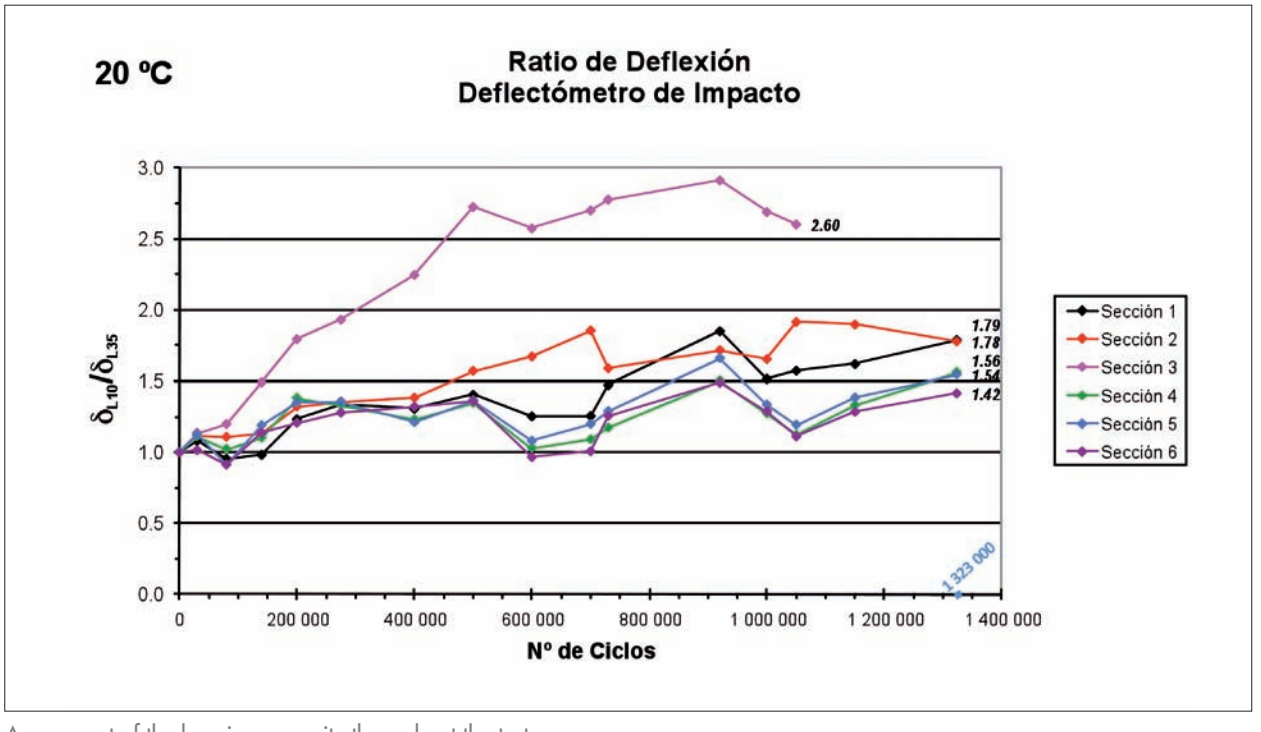
• Bearing capacity of the pavement, using falling weight deflectometer.
• Permanent surface deformation, using laser transverse profiler.
• Surface cracking, recorded by visual inspection.
• Longitudinal unevenness, in terms of the IRI, measured using dipstick profiler.

This information is further complemented by the information obtained from a total of 248 sensors embedded in the different layers of the pavement. Therefore, the deterioration shown on the graph of the bearing capacity evolution can also be addressed from the response of some sensors; see example for sensor 12CT31, which measures the vertical stress on the top of the subgrades under the effect of the vehicles.

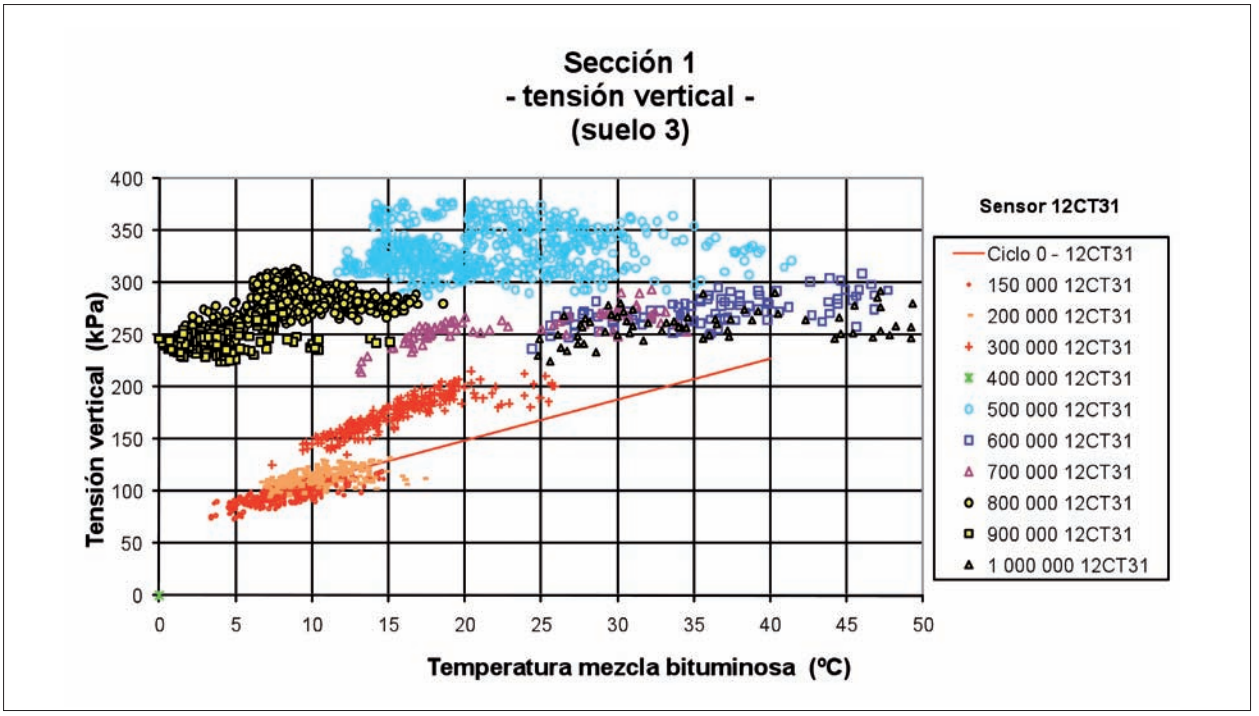
Thanks to all this information, it is possible to obtain conclusions which are directly applicable to pavement engineering. The following are the three main conclusions obtained preliminarily to this test:

• High bearing capacity of cement-stabilised soil S-EST3, over the initial expectations. Thanks to this, first of all, the different subgrade alternatives using this material included in the code 6.1 IC can be validated.
• Localization of permanent deformations in the first centimetres of the capping layer. This aspect redefines the role of intermediate and lower layers within the platform from an alternative perspective to the traditional one.
• Limited efficiency of tack coat between cement-treated layers and layers of bituminous mixtures. This aspect is extremely relevant to the performance of semi-rigid pavements.

The development of the three aforementioned aspects requires in turn a significant effort for their modelling. The calibration of a mechanical model on the bases of measurements taken during the test enables the extrapolation of the results to other types of sections and/or weather conditions. Likewise, it allows the optimization of the materials used in the pave-



Assessment of the bearing capacity throughout the test.



Example of the results of one of the sensors.

ment and in the platform, in terms of quality and thickness, and provides objective criteria for their design and conservation throughout their service life. The final objective of the modelling is the prediction of the evolution in time of the different distress mechanisms that can develop in each type of pavement.

CENTRO DE ESTUDIOS DE

TÉCNICAS APLICADAS

ENVIRONMENTAL MANAGEMENT SYSTEM AT THE CETA

After the approval of the CEDEX's environmental policy in November 2007, the CETA has undergone a process for conditioning and adapting its activities to the objectives arisen from the said policy.

The process for the improvement of interventions from the environmental point of view has continued. Having overcome both internal and external auditing processes as stated by the regulations, the process has been completed obtaining the certification corresponding to standard UNE-EN ISO 14001:2004.

This entails continuous attention to compliance with environmental objectives. These objectives are mainly centred on the rational reduction of resource consumption, particularly paper, ink, solvents, reagents, etc. , the gradual substitution of paper by digital formats, as well as the reduction of water and electric energy consumption, without infringing in any case the compromises adopted by the Centro with his clients. These objectives are completed by a gradual reduction of the production of dangerous waste, managed according to the requirements of the aforementioned regulation.

The environmental commission of the Centro meets periodically. Among its functions, this commission is responsible for setting the annual objectives, as well as defining the indicators according to which the compliance with the objectives is to be assessed.

ENVIRONMENTAL ENGINEERING

In 2009 the CETA has developed a quality management system according to UNE-EN ISO 9001:2008, specific for the area of Environmental Engineering, supervised by the Management of the Centro.

In June 2009 an agreement was signed between the Dirección General de Calidad y Evaluación Ambiental (DGCEA) of the Ministerio de Medio Ambiente, y Medio Rural y Marino (MARM) and the CEDEX. The subject of the agreement was the Assignment of Management for technical assistance, research and technological development on aspects within the scope of the General Directorate. In this context, under the framework of Activitiess 3, 4 and 6 of the Area, the CETA has issued ten reports that verse, in general, on the phase of preliminary consultation for environmental impact studies, construction-phase environmental monitoring and environmental databases. Furthermore, the Centro has drafted a protocol for the conditioning of linear infrastructure banks.

The Centro has completed for the Dirección General del Agua (DGA) of the MARM the work on environmentally monitoring desalination plants in the Balearic Islands. Likewise, it has drafted technical recommendations for studies and design projects of desalination plants subject to environmental impact assessment.

The work for obtaining the environmental flow regimes in inter-communitarian river basins has been coordinated. This has entailed the study and development of a national plan of water-regions for its application in the calculation of the aforementioned flows. Likewise, the Centro has done further work on the riverbank vegetation descriptive programme, having finished this year the work on all Spanish rivers, including the rivers in the different islands. For this General Directorate, the CETA has also developed evaluation methodolo-

Water intake well of a sea water desalination plant.

LEFT
Pre-treatment deposits in a sea water desalination plant.

RIGHT
Reverse osmosis modules in a sea water desalination plant.

gies to assess damage in forests associated to rivers and has made progress on the National Catalogue of Natural River Reserves, as well as on the development of laser technologies (LiDAR) for managing and cataloguing riverbank plants. This latter work has yielded a new application for the automation of ecologic and geomorphologic parameter measurements in water environments.

For the Dirección General de Sostenibilidad de la Costa y del Mar (DGSCM), the Centro has developed the ecologic definition of vegetation in dunes and marshes along the Catalan coast. By commission of the Sociedad Pública de Gestión Ambiental, Viveros y Repoblaciones de Navarra, S.A., the project for the environmental improvement of the meander of el Plantío (Navarra) has been completed.

AIR QUALITY AND CLIMATE CHANGE

The CETA has continued developing work on the following two strategic lines:

- Broadcasting of the work developed by the CEDEX in connection to climate change.
- Transport emissions in Spain.

The objectives pursued with the Estrategia de Difusión y de Comunicación (Strategy for Broadcasting and Communication) are, in the first place, the education and dissemination in aspects related to impact of transport-related activities on the emission of greenhouse gases; in the second place, the promotion of population sensitivity towards the impact of everyday activities.

Studies of geo-morphologic conditions originated by reservoirs.

The broadcasting channels used for these purposes have been the publications developed by the CEDEX, together with a number of scientific journals specialised in this subject and conferences aimed for related organizations and professional institutions within the transport sector.

In agreement with the strategic line for transport emissions, the Inventarios Nacionales de emisiones contaminantes a la atmófera (Spanish National Inventories of Polluting Emissions to the Atmosphere) of the MARM have been revised. The road transport sector has been revised with the aid of the COPERT IV application in order to, first of all, quantify the emissions generated by this sector, and, secondly, to propose strategies for the improvement of the quality of life. With the aim of providing support in planning and forecasting road transport, the Centro is exploring new tools for measuring emissions in connection with a number of road transport contexts: heavy traffic roads, mountain roads, etc.

The Division has participated as "mobility coordinator" in the programme "Financial support for pilot programmes to promote sustainable mobility in urban and metropolitan environments" of the Ministerio de Fomento (Ministry of Transport). Seven projects within this scope are currently being coordinated by the Centro.

NOISE POLLUTION

The Division of Noise Pollution has developed work for the DGCEA in relation to the implementation of the Law of Noise and its Regulations, in particular, studies on the development, compilation and broadcasting of strategic noise maps for main roads, main railway lines, airports and build-ups, as well as the maps corresponding to plans against noise.

The Division has revised the Sistema Básico de Información sobre Contaminación Acústica (Ba-

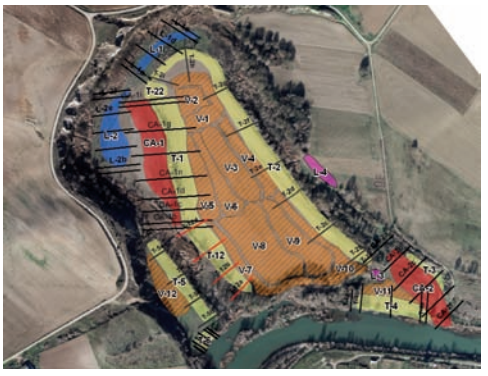
sic System of Information on Noise Pollution). Its contents have been updated and new graphic design that allows access to graphic information has been implemented.

For the Dirección General de Carreteras (DGC, General Directorate of Roads) of the Ministerio de Fomento, the Division has provided technical advice for the implementation of the Plan de Acción contra el Ruido (PAR 2008-2012, Action Plan against Noise), approved by the General Directorate at the end of 2008. Also for the DGC, the Division has continued working on informing the general public through the website EGRA.

ISOTOPIC APPLICATIONS

The Centro has developed the tasks included in "Agreement between the MARM and the CEDEX for technical assistance, research and technological development in the fields of responsibility of the General Directorate of Water (2007-2012)". This work consists of the analysis and radiologic study of continental water in Spain, as well as supply water managed by the Association of Canals of the Taibilla. The Centro has also carried out the work under the specific conventions for the radiological monitoring of the rivers Tajo and Ebro around the nuclear power stations of Almaraz, Santa María de Garoña and Ascó. Likewise, the Centro has developed the work for the Convention with the Consejo de Seguridad Nuclear (CSN, Council for Nuclear Safety) "Technical Assistance in the radiological monitoring of the water environment" and for "The development of an environmental radiological monitoring programme for the water environment in the sparse network".

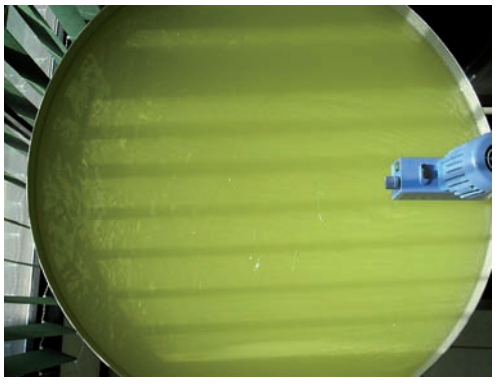
In order to meet the requirements of these conventions, a high number of water samples taken from over 200 points within the continental, coast and supply water networks have been analysed. The studied parameters were alpha, gross beta and residual beta activity indices, gamma spectrometry and tritium concentration. The concentration of cesium-137 was measured in continental and sea water samples taken from the sparse network.



Layout of the design for the river restoration of the El Plantío meander (Mendigorria-Mañeru, Navarra).

Around one thousand water samples have been analysed, having performed over four thousand radioactivity tests and introducing more than thirty thousand pieces of data in the database. A total of 18 reports have been written on the bases of these data. A part of the results obtained from these networks are sent to the European Union by the CSN, in agreement with articles 35 and 36 of the EURATOM treaty.

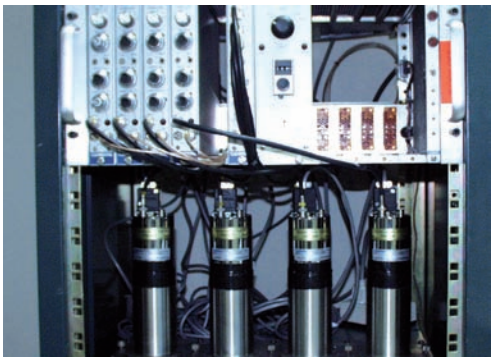
The experts of the Division of Isotopic Applications collaborate in national working groups on regulation for environmental radioactivity laboratories and take part in international working groups to compare the adopted measures. The Division has completed the research work for initiating the measurement of alpha spectrometry in Spanish water using the liquid scintillation counting technique. Furthermore, it has carried out further experiments on real samples from the river Duero basin featuring high concentrations of natural radionuclide (Radon). Thanks to these experiments it is possible to study the factors that influence the measurement and precision of the method.



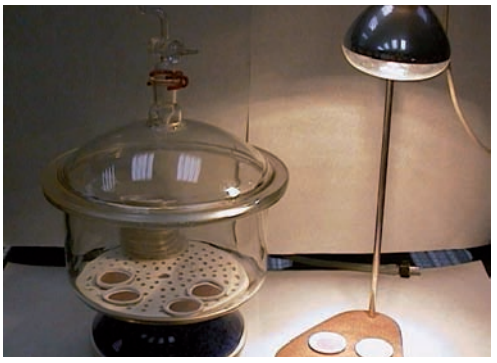
LEFT
Intermediate stage in the preparation of a water sample for the measurement of cesium-137 activity in continental and marine water (top view).

RIGHT
Gamma radiation detectors.

LEFT
Electronic chain for determining the gross alpha activity index.



RIGHT
Drying process for the samples prepared using the gross alpha co-precipitation method.



It is worth mentioning the effort put by the radiological monitoring laboratory into the drafting of manuals, procedures and technical codes for obtaining the accreditation by the Entidad Nacional de Acreditación (ENAC, Spanish Accreditation Entity), in accordance to the regulation UNE-EN ISO/IEC 17025:2005.

As far as information management is concerned, the Centro is working on the development of a project for the transformation and update of the computer application called Meragua. This application is currently the tool used for managing samples, as well as calculations and result storage in Visual Basic 6, thanks to new code on the .NET platform.

The results of the radiological monitoring carried out before 1999 are currently being transferred to the database of the Consejo de Seguridad Nuclear. 1999 was the year when the CEDEX signed the agreement for the "Technical Assistance to the Consejo de Seguridad Nuclear in the programmes for radiological monitoring of the water environment".

In the field of isotopic hydrology and within the framework of the convention signed with the DGA, called "Technical Assistance, research and technological development in the field of management of the water public domain and operation of the infrastructure. Activity 6.-Aquifers and wetlands", the following activities have been developed:

Hydrologic, radiologic and isotopic characterization of groundwater bodies of Sayago (02.40) – Vitigudino (02.53) – La Fuente de San Esteban (02.59) – Ciudad Rodrigo (02.63) – Las Batuecas (02.65), all of them located within the river Duero basin. The objective of this work was to assess the natural radioactivity of groundwater that can be delivered through supply networks. Data was obtained regarding the age of the underground water. The concentration of radon was determined using different techniques: gamma spectrometry, liquid scintillation counting and in-situ test. The three techniques have yielded good results.

The Centro has carried out a study for the hydrologic and isotopic characterization of the Groundwater Bodies (GWB) of Mancha Occidental II (041.006) – Sierra de Altomira (041.001) – Campo de Montiel (041.010). This work was part of the hydrologic and isotopic characterization of the GWB Mancha Occidental II, both of the lower carbonated Mesozoic aquifer and the upper detrital and carbonated Mio-Pliocene aquifer. The goal of this characterization was determining its connection with adjacent GWB, Sierra de Altomira and Campo de Montiel, and extending the available information on the hydrological functioning of the system and to establish the possible interactions between the three groundwater bodies.

Under the framework of the Convention "Technical assistance, research and technological development on the field of hydraulic infrastructures. Activity 11.- Study of reservoir leaks", the following studies have been carried out:

Study of the Yesa reservoir, river Aragón (Navarra-Huesca) to learn about the permeability of the materials flooded by the reservoir and their behaviour under an extension of the reservoir.

Study of the Tous reservoir in the river Júcar (Valencia/València), focused on locating the origin of the springs found in the vicinities of the reservoir and the possible connections between the springs and the reservoir (in particular on the right-hand bank). Furthermore, the origins of the springs that appear on the Júcar-Turia canal have been identified and the properties of the subsoil have been surveyed. The purpose of the lat-

ter activity was to locate the fractures or karsts through which water from the reservoir infiltrates into the Júcar-Turia canal, in order to plan future work for sealing these cracks via injections.

Study of the Bellús reservoir in the river Albaida (Valencia/València), performing the hydrologic and isotopic characterization of the surroundings of the reservoir. This characterization has been used to confirm the hydro-geologic state described in earlier studies, as well as to update the information available on this area.

Study of the Ulldecona reservoir in the river Cenia (Castellón/Castelló), locating the origins of the springs found in the surroundings of the reservoir and the possible connection between springs and reservoirs.

Study of the Loriguilla reservoir in the river Turia (Valencia/València), performing a revision of the hydrologic and isotopic characterization of the surroundings of the reservoir. This study has included surface and underground water and has enabled the update of available information on this area.

Study of the Gargáligas reservoir (Guadiana River Authority-Badajoz), obtaining results for the hydrologic and isotopic characterization of both surface and underground water in the surroundings of the reservoir. The objective of this work was to assess the relationship between the water in the reservoir and the water of points located downstream from the reservoir.

Study of the Valcomuna reservoir, locating the origin of the springs found in the surroundings of the reservoir and the possible connection between springs and reservoir.

Study of the Giribaile reservoir in the river Guadalimar (Jaén), revising the hydrologic and isotopic characterization of the surroundings of the reservoir, including surface and underground water. The available information for this area has been updated.

Study of the Puentes reservoir in the river Guadalimar, locating the origins of the leaks/springs near the drains of the reservoir gallery.

Study of the Trapa reservoir (Zaragoza) to locate the origins of the springs found in the surroundings of the reservoir, near the left-hand

Tous reservoir.

bank, and the possible connection between springs and reservoir.

The experts at the Isotopic Applications Laboratory have analysed samples to identify stable isotopes (deuterium and oxygen-18), tritium, carbon-13 and carbon-14 as part of all the studies and conventions carried out in the field of Isotopic Hydrology, as well as for all the Radiologic Monitoring conventions on Spanish waters.

Within the convention for collaboration between CEDEX and IGME (Instituto Geológico y Minero de España, Spanish Geological and Mining Institute), the aforementioned analyses have been performed for the following projects:

Maestrazgo-Sierra de Irta, Sequía-Valencia, Murcia, Loma de Úbeda, Humedales-Ebro, Burgos, Sierra de Gador-Campo de Dalias and Hydrogeologic North of Gran Canaria; as well as analyses for prlvate companies.

The Centro has purchased a Stable Isotope Ratio Infrared Spectrometry, latest technology in isotope analysis. The device is currently being tuned for its use.

The Red Española de Vigilancia de Isótopos en la Precipitación (REVIP), called in English SNIP (Spanish Monitoring Network for Isotopes in Precipitation) is active. This network focuses on the isotopic analysis of precipitations in the Iberian Peninsula, in collaboration with the Agencia Estatal de Meteorología (AEMet, Spanish Meteorology Agency). This network comprises sixteen stations, covering a broad geographical area (North-South and East-West) and a broad climate range (station in wet and dry area, inland and on the coast, Atlantic and Mediterranean climate). This data is enormously useful in the study and behaviour of the water cycle in the Iberian Peninsula. Their study is promoted by the WMO (World Meteorological Organization) and the IAEA (International Atomic Energy Agency). Both organizations own a global

LEFT
Water springs downstream from the Ulldecona reservoir.

RIGHT
Loriguilla reservoir.

network of isotope in precipitation (GNIP network). The data obtained in Spain for this network is delivered by the Isotopic Applications Laboratory. A coordinated project has arisen from this collaboration. This project, called Geoestatistical analysis of spatial isotope variability to map the sources of water for hydrological studies. F3.30.16, is run by the International Atomic Energy Agency and the Division participates in it, together with other fourteen members of United Nations.

TRAINING AND DOCUMENTATION OFFICE

The CEDEX's Scientific and Technical Information and Documentation Programme has focused its activity in particular on three areas:

- Participation in international networks and projects related to information, documentation and data bases in various fields of civil engineering and associated environments.
- Implementation and development of information systems on Internet about continental water, roads and transport.
- Development and update of terminology tools (thesaurus and multilingual dictionaries) in the field of transport and roads.

In the field of continental water, and in agreement with the conventions signed with the DGA:

The Office has developed the contents and services on the Internet website about continental water in Spain, Hispagua. New topics have been introduced, as well as new functions and web application. Furthermore, bulletins and specialised monographs on various aspects of water management have been published.

The Office has taken active part in the European cooperation project EMWIS (Euro-Mediterranean Information System on know-how in the Water sector). The Hispagua website is the National Focal Point of the system and the CEDEX is the member of the Technical Unit in charge or managing it. Within the activities that are part of this project, the CEDEX has taken part in the 13th meeting of the Steering Committee, held in Monaco, and the 9th National Focal Points Coordination Seminar, held in Niza.

The CEDEX has also taken part in the SIAGUA information system (Sistema Iberoamericano de Información sobre el Agua, Ibero-American Water Information System). Within this virtual network, the Office works on coordinating and planning the system, as well as managing the International Focal Point of the network, of which it is responsible. SIAGUA has been presented in the 5th World Water Forum, under the section 6.1 Education and Capacity Development Strategies. Furthermore, members of the CEDEX gave conferences at the Spanish Government Stand in this Forum on issues related to the development, outreach and assessment of the water information systems managed by the CEDEX: Hispagua, SEMIDE and SIAGUA.

The contents and services of the DIRCAIBEA Website, that is, the website of the Board of Directors of roads in Iberia and Ibero-America, have been developed, updated and extended. The Office has also updated the contents of the official website for the 18th International Symposium on Transport Economics and Policy, organized by the OCDE and held in Madrid.

As part of the CEDEX's publishing programme, the Centro has published three ordinary numbers of the Ingeniería Civil magazine, numbers 153, 154 and 155, and a monographic issue about Geothermal power, number 156, which included a total of 46 technical papers. Furthermore, the Centro published a number of books and other texts that can be found listed on the Annex.

The Office has worked on the CEDEX's Library Network, responding to user requests made either by the members of the CEDEX´s staff or by universities, enterprises, individuals and general public who have requested services from the libraries.

The CATA data base has been extended with 1620 new entries. Information about the data base can be found on the table below.

The statistics on libraries requested by the INE (Spanish National Statistics Institute) in 2009 has yielded the results compiled in the following table:

Service points	7
Access	Free
Total usable surface area (m²)	1.541
Total number of reading spaces	63
Shelf length taken up by the collection (m)	
• Free access:	3.495
• Deposit:	2.203
Microfilm readers	3
Photocopiers	7
Total number of computer terminals	23
Scanners	6
Total number of volumes in the digital catalogue	152.741
Books and pamphlets before 1901	180
Tittles of periodicals	
• Ongoing	433
• Terminated	1.362
Document management system	ABSYS 7.0

As far as computer resources are concerned, the Intranet of the Library Network has been integrated in the CEDEX's new intranet, under the Knowledge section. It can be found under the following address: http://intranet.cedex.es/Biblioteca/. This address provides access to the online catalogue for the entire Network and to the Web of Knowledge (WOK), a platform compiling references to the main scientific publications of all disciplines since 1945. In addition, the following full-text resources can be accessed:

- Electronic periodicals
- Standards
- Technical reports by the CEDEX (full text access only with permission and IP address identification).

The CEDEX's Library Network will be part of the project of the Dirección General del Libro, Archivos y Bibliotecas (DGLAB, General Directorate of Books, Archives and Libraries) to be included as a digital catalogue into a single access point for all state-owned libraries. This will be done through a collective catalogue or equivalent system, available online, to consult the collections of all the libraries under the National Government or any public entities.

As part of the Training Programme, the CEDEX has organised the selective courses for accessing the state bodies of Civil Engineers, as well as a number of other courses and events related to the CEDEX's fields of work.

Three long international courses (each over five hundred taught hours) have been organised, as well as an international symposium, international conferences and other shorter courses. Furthermore, under the Ibero-American Water Training Programme, sixteen courses have been run in different Latin-American offices of the Agencia Española para la Cooperación y Desarrollo (AECID, Spanish Agency for Cooperation and Development). Other courses on technology transfer have also been run in collaboration with the AECID.

In the national context, the CEDEX's Training Programme has organised a total of one seminar, four courses and five conferences. Furthermore, it has organised various activities in collaboration with external entities, adding up to a total of more than 50 events.

As far as the CEDEX's internal ongoing training is concerned, the line of action of previous years has been kept up. The new initiatives have mostly focused on offering courses online, while disseminating the professional interest of these activities. A total of 53 online courses were run throughout 2009.

Initial distillation of the electrolytic concentration process for tritium.

Second distillation of the electrolytic concentration process for tritium.

Liquid scintillation counting machine for measuring carbon-14 and tritium.

TOOLS FOR CALCULATING GAS EMISSIONS IN TRANSPORT

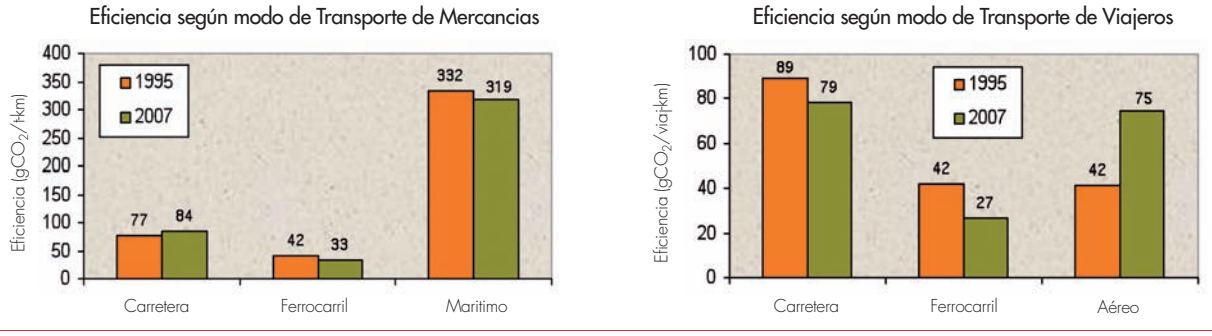
Modern society is strongly concerned about measuring the impact caused by human activity, because the impact that can be measured can be improved and efficiently confronted. Thus, polluting emissions in Spain and in the European context are measured using the CORINE AIRE Inventory. This Inventory has enabled the quantification of emissions since the year 1990 until today, in response to the obligations imposed by the European Union. Spain's current compromises in atmospheric pollution are of such importance that a deeper revision must be carried out, in accordance with the variables that define the country's economic reality.

Transport is the main energy consumer in Spain, with over 38% of the total. 65% of this amount originates from the road sector. Over the last few years, mobility in Spain has grown for all means of transport, both for passengers and freight. The road sector has received the largest demand, and this has meant an increase in the emissions generated by transport. These emissions represent approximately 26% of the total greenhouse gas emissions. In addition, transport is deeply dependant on fossil fuels, while the availability of these fuels in the future is not granted. This diagnosis has motivated the CEDEX's Climate Change Division to consider policies for saving energy, for diversifying alternative and renewable energy sources and for managing transport offer and demand.

This concern has brought the Area to explore tools for quantifying greenhouse gas emission, compiling and assessing the evolution over time of various air quality and greenhouse gas emission indicators, within the field of transport in Spain, in particular, in the road sector. Besides, the quantification of emissions generated by each different means of transport has been used for comparing their efficiency and distinguishing between passenger and freight transport. In the case of the road system, the efficiency of the vehicle pool has been compared with that of neighbouring countries.

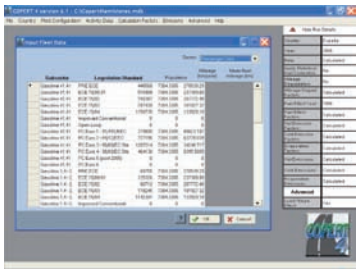
This analysis has highlighted the disparity between the different official data bases about transport and the environment. These differences are partly consequence of the distribution of power and responsibility between the government administrations dealing with land related issues (the European Union, the Nation, the autonomic communities and the local administrations). This circumstance is evidenced by the gaps of information in the available sources, as well as by the incongruence found between them. This approach has aimed to emphasize the need to complete and homogenize the initial data in the assessment of air quality indicators related to transport. This will yield a diagnosis that is closer to the current state in Spain and surrounding countries.

Progress has been made in the operation of tools for quantifying emissions associated with different behaviour in the field of road mobility, COPERT IV. This mechanism also



Graph 1. CO_2 emissions per passenger.km and ton.km from the different means of transport for the years 1995 and 2007.

Source: National Emissions Inventory (MARM) for the emission estimate, and Postal Transport and Services (Ministerio de Fomento) for estimates of passenger.km; with the exception of traffic and emissions from railway transport: data obtained from Renfe-Operadora.



Graph 2. Data entry window for COPERT IV.

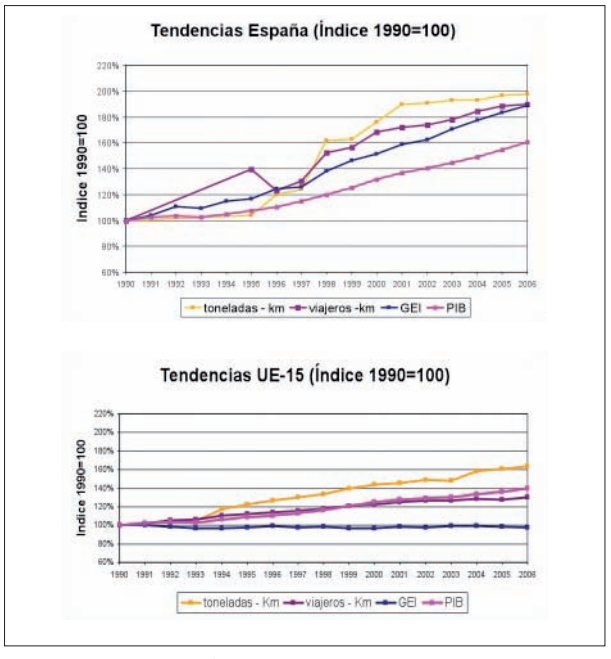
serves as a means to propose mobility strategies that can help improve the quality of life. The application of the COPERT IV program has required the analysis of the country's characteristic data on climate conditions, on the categorization of the vehicle pool, the vehicle type and fuel consumption, on the mobility of each type of vehicle, on the road types, etc.

Work has been done, not only on mobility efficiency in the Spanish context and on broadcasting of good practices towards a more sustainable mobility, but also on exploring the programme applied in the European scale for reducing impact on air quality and improving energy efficiency. The information from air quality indicators in different countries of the EU has been the starting point for evaluating the good practices that contribute to the redirecting of environmental behaviour. It is the aim of the CEDEX to continue working on this line of research in order to complete the compilation of databases, as well as the information gaps, and to improve our knowledge of implemented trends in the fields of mobility and environmental impact throughout Europe.

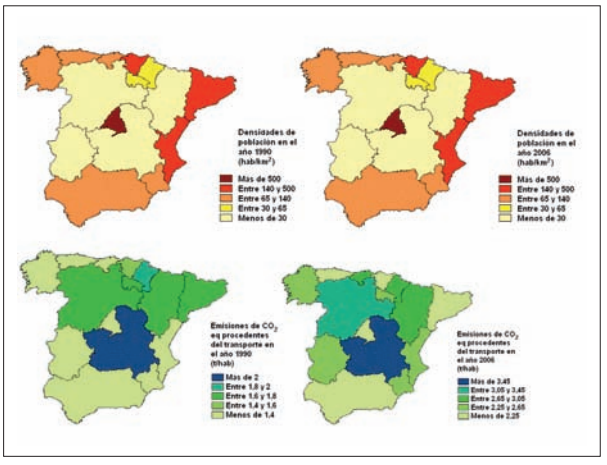
The study carried out at the scale of autonomic communities, having previously assessed the vehicle pool and the mobility, has served for deepening into the analysis of emissions from road transport. Further responsibilities of the division within this analysis are informing and training autonomic communities in the calculation of atmospheric emissions following the revised methodology. This will contribute to the standardization of criteria under continuous knowledge feedback and renewal.

Furthermore, the Division aims to take part in working teams together with organizations within the road transport sector, professional institutions, transport operators, traffic control bodies, even observatories for mobility and transport sustainability and any other entity interested in these issues. This will be a means for sharing progress and for mutual enrichment that may generate synergies for transport demand planning policies.

Likewise, the CEDEX aims to contribute devising a methodology to be implemented in a calculator for polluting gas emissions from each means of transport. Such a devise will help systematically, meticulously and efficiently assess and compare emissions of greenhouse and other polluting gases. Finally, this study can be translated into energy consumption levels of the different types and means of transport.

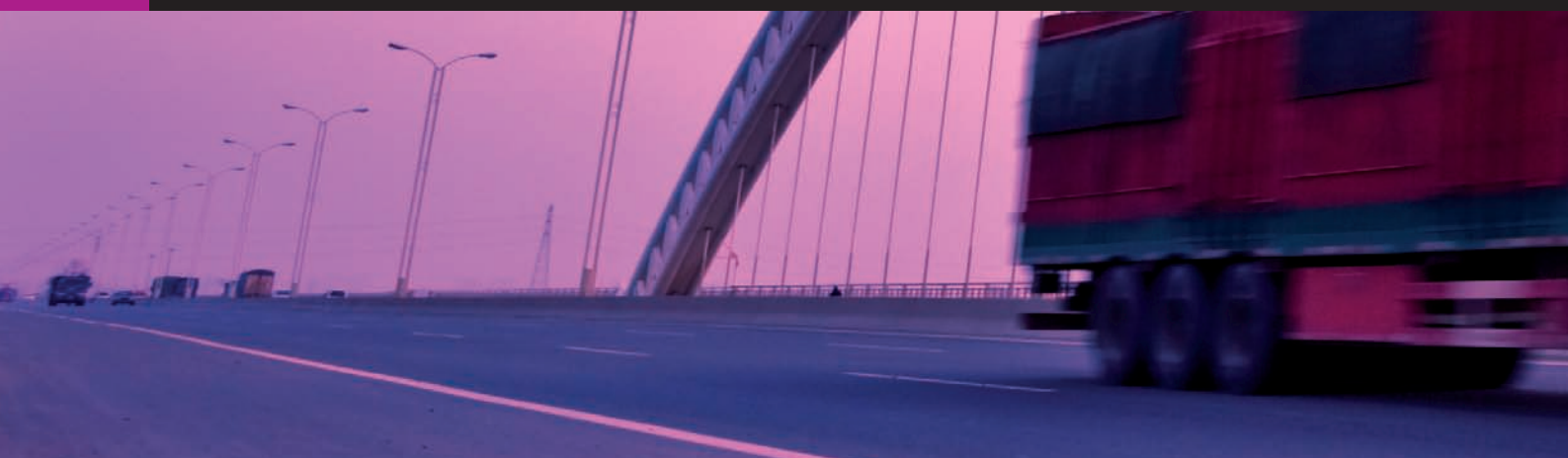


Graph 3. Evolution of greenhouse gas emission, gross domestic product, ton.km and passenger.km for road transport in Spain and in the EU-15 for the period 1990-2006.
Source: EU-ROSTAT, AMECO, Data Service EEA and European Commission.



Graph 4. Comparison between population density and equivalent CO_2 emissions per habitant from transport in the different autonomic communities for 1996 and 2006.
Source: INE and MARM.

LABORATORIO CENTRAL DE
ESTRUCTURAS Y MATERIALES



The activities carried out throughout 2009 by the Laboratorio Central de Estructuras y Materiales are related to technical assistance, experimentation, research and drafting of regulations, all in the field of construction materials and civil or building engineering structures.

STRUCTURES

In the field of structures, and in connection to the technical assistance offered to the Dirección General de Carreteras (DGC, General Directorate of Roads) of the Ministerio de Fomento (Ministry of Transport) on bridge and structures related issues, the Laboratorio has made progress in a number of projects. Furthermore, the Laboratorio has worked on the inspection and auscultation of damaged bridges of the national road network, such as the Rambla del Poyo viaduct in Riba-roja de Túria (Valencia/València) and the Alcazaba viaduct in the Mediterranean motorway (A-7) in Almería. The latter was inspected after ground movement below the foundations. Other examples are the Villajoyosa/la Vila Joiosa underpass (Alicante/Alacant) on the N-332, the cable-stayed bridge over the river Barxell on the N-340 in Alcoy/Alcoi (Alicante/Alacant) and the bridge of the A-67 over the Santander-Palencia railway line in Cantabria. Two tunnels were assessed in collaboration with the Laboratorio de Geotecnia: the tunnels of Los Yébenes (Toledo) and of Torrelavega (Cantabria). Likewise, the Laboratorio they were carried out the auscultation of the bridge of Alconétar over the river Tajo and the viaduct over the river Almonte, both on Ruta de la Plata (A-66) through the province of Cáceres. The campaign was completed with the inspection of the underpass in Benidorm on the N-332 and two overpasses in Toledo crossing the city's ring road.

Moving to a different field, the Laboratorio has carried out dynamic tests were carried out on the Fernando Reig bridge in Alcoy/Alcoi, after the collision of a truck against one of the cables. Further dynamic tests have been carried out on a number of overpasses in Toledo that featured severe damage.

Work has been done on a number of projects for the Administrador de Infraestructuras Ferroviarias (ADIF, Spanish Administrator of Railway Infrastructures). This work includes the monitoring of the bridges over the river Llobregat using remote-recording instrumentation. The monitoring campaign was completed this year. As far as the work done on the bridge of Candí (Tarragona), on the Madrid-Barcelona AVE high-speed railway line, the Laboratorio has audited the new instrumentation to be installed at the new location of the bridge and has carried out performed two new dynamic tests corresponding to two structural conditions of the viaduct.

The work within the Assignment by the Gerencia de Infraestructuras y Equipamientos de Cultura (Administration of Cultural Infrastructure and Facilities) of the Ministerio de Cultura (Ministry of Culture) has consisted of projects such as the assessment of existing damage on certain structural elements of the Bojes patio yard in the Museum of Fine Arts of Seville and of the structural response of floor structures in the Palace of the Duque del Infantado in Guadalajara. Both assessments were performed by load tests. Work continues on the assessment of the struc-

Installation of sensors for cable vibration monitoring.

Acceleration sensor.

ture of the warehouse in San Fernando de Henares and of the buildings managed by the Gerencia in Madrid.

The Laboratorio, together with specialised private companies, is developing work in the field of dam auscultation, included in the convention signed with the Dirección General del Agua (DGA, General Directorate of Water) of the MARM (Ministry of the Environment). This work entails the development of a new auscultation management model called GEISER, based on the SIGAP (Sistema Integral de Gestión para la Auscultación de Presas, Integral System for Dam Auscultation Management), developed within the Laboratorio Central de Estructuras y Materiales. The objective is to implement the new system in the river Ebro basin, to enable the management of the basin via the Internet. The original SIGAP program, currently implemented in other river basins, is being further improved and its operation is coordinated and monitored from the Laboratorio Central, as it is expected that it stays in use.

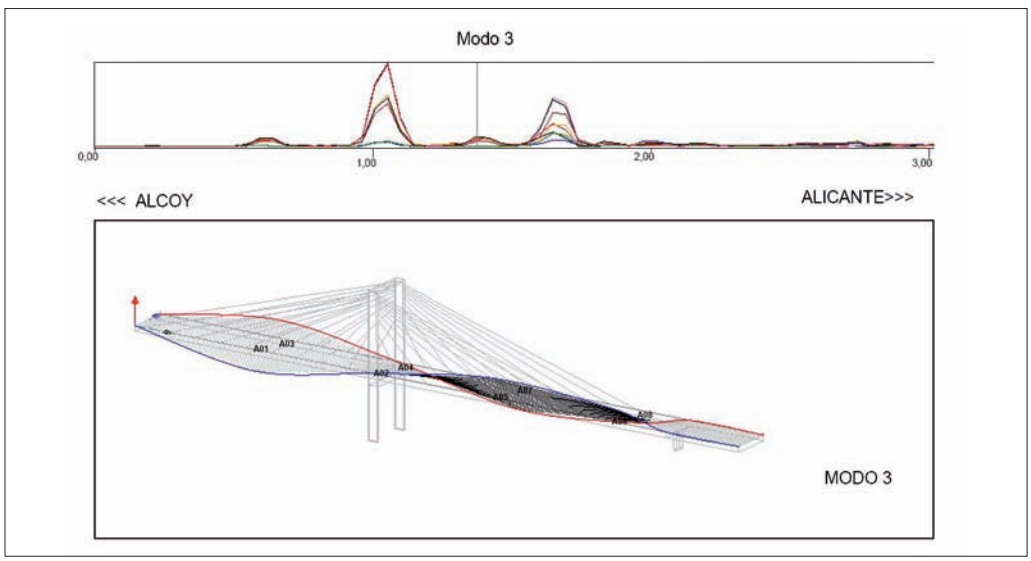
A large number of vibration tests on the dynamic shaking table have been carried out throughout the year. Some of these tests were carried out regarding on railway rolling elements stock both for Spanish and international installations. The former include the Metro of Madrid, and the latter, amongst others, the cases of New York, Algiers, Mexico and China. Other dynamic tests are the fatigue tests on radar antennae for the Spanish Army (Juan Carlos I aircraft carrier) and on equipment for wind turbines (three-phase transformers). Further tests were carried out for the Suisse companyCompany ABB on traction electric transformers for urban trains.

In conjunction with the Laboratio de Geotecnia, the Laboratorio Central has installed in the building for railway infrastructure tests a model of a railway track with bituminous sub-ballast. Three test zones with different sub-ballast thicknesses have been implemented. Throughout the second semester of 2009, the transit of four million axes was simulated using the standard train running at 300 km/h on the middle section of the equipment, registering physical variables with 150 sensors. The reaction frame structure had been previously modified to handle simulations of up to 400 km/h. Likewise, the system for measuring ballast acceleration was developed using tri-axial accelerometers embedded in individual ballast stones. The software for processing these measurements was also developed.

CONSTRUCTION MATERIALS

The most important work of the Laboratorio Central in the field of construction materials has been the following:

Modal shape calculation for a cable-stayed bridge.



Load test at the Infantado Palace (Guadalajara).

For the Dirección General de Calidad y Evaluación Ambiental (DGCEA, General Directorate of Environmental Quality and Control) of the Ministerio de Medio Ambiente, y Medio Rural y Marino (MARM, (Ministry of the Environment), the Laboratorio Central has prepared the *Catálogo Actualizado de residueos utilizables en construcción* (*Updated catalogue of by-products usable in construction*). This catalogue has taken the form of a computer application accessible on Internet through the CEDEX's main website. The line of research on the field of recycled aggregate use in concrete has been continued under the framework of the CLEAM project of the CENIT programme, financed by the Ministerio de Industria, Turismo y Comercio (Ministry of Industry). Eleven Spanish universities and research centres take part in this project under the technical coordination of the CEDEX. The project pursues the deepening of knowledge in the fields of recycled aggregate use for structural and non-structural concrete with respect to durability. The Laboratorio Central has also taken part in another research project on the use of recycled aggregates in non-structural concrete. This project, called NONESCON, has been funded by the Ministerio de Fomento and was completed this year.

The Laboratorio Central has completed the study of the deterioration/damage of concrete in dams. This project, commissioned by the DGA, aimed to learn more about the deterioration of this kind of concrete by studying a series of dams featuring a range of damages. The objective is to establish the criteria and requirements of concrete to be used in the construction of new dams. Eleven damaged dams have been studied throughout the whole project. These studies have provided a deeper knowledge about the alkali-silica reaction. The great progress made in this field has been summarized in a doctoral thesis, close to being completed, and in a *suficiencia investigadora* report (DEA, pre-doctorate research work) on the study of slow-reaction aggregates.

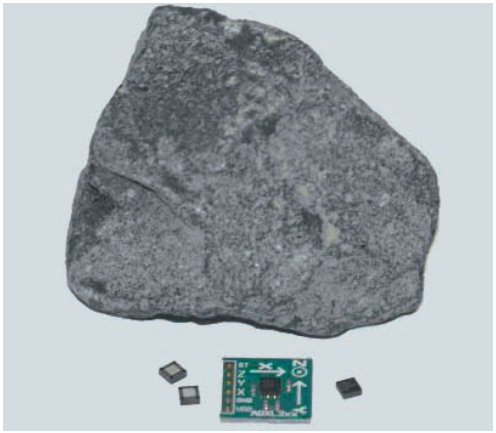
The Laboratorio also collaborates in the study of normalised sand behaviour with respect to durability, a project developed for the Instituto Español del Cemento y sus Aplicaciones (IECA, Spanish Cement Institute).

Lastly, in the field of reinforced concrete performance in the marine environment, the Laboratorio has completed the analysis of the performance of concrete cofferdams underwater and when subject to tidal range. Furthermore, a study of concrete behaviour in two overwater port piers has been started. Both studies were commissioned by the Puertos del Estado (National Ports).

The division of construction materials has It was also carried out a study of the damage in a concrete railway tunnel, commissioned by ICYFSA. The physical and mechanical properties of the concrete were analyzedcalculated, the depth of sulphate penetration was measured, as well as the rate of the sulphate attack progress.

The Laboratorio Central has continued working on quality monitoring of polymeric materials for dam waterproofing. For the DGA, it has carried out the

Vibration test on the shaking table.



LEFT
Accelerometers to be embedded in ballast stones.

RIGHT
By-products re-usable in construction.

inspection of a large number of dams, taking samples and defining material properties. Likewise, the Laboratorio has checked the suitability of these materials for new dams and reservoirs, such as those os Alisarejos, Bonales, Calderones, Capdepera, Covachas, Inca, Lomos, Luis Alted, Parejas, Peguera, Puente Porto, Quebrás, Robles and Zacillo.

Thanks to the experience gained through this work, it has been possible to draft, under commission of the MARM, the *Manual de diseño, construcción, explotación y mantenimiento de balsas* (*Manual for reservoir design, construction, operation and maintenance*). This document comprises ten chapters drafted by different Centros and Laboratorios within the CEDEX. The completion of the document was marked by the celebration of a Technical Conference held at the CEDEX for the presentation of the final draft.

In this same context, the Laboratorio continues collaborating with the Universidad Complutense de Madrid (UCM) on extending the knowledge about polymeric geo-synthetic barrier decay. These barriers are made of plasticized (PVC-P) Poly(vinyl chloride) and were studied using advanced analysis techniques, such as Fourier Transform Infrared Spectroscopy (FTIR), gas chromatography (GC) and mass spectroscopy (MS). The results obtained in these studies are compiled in the aforementioned Manual, which also gives the guidelines for improving durability in these macro-molecular materials.

The work for the company CETCO Ibérica studying bentonitic geo-synthetic barriers has continued.

In the field of materials used for road equipment, the Laboratorio Central has carried out activities jobs such as the tests for the certification of vitreous micro-spheres used in road signs. Similarly, it has carried out continued with further tests for defining the properties of materials to be used for making road signs, boards and portal frames, as well as for defining the properties of retroreflective materials comprised of vitreous micro-spheres or micro-prisms. Most of these tests are performed for obtaining quality certificates (AENOR, Bureau Veritas), but are often also requested by manufacturers and private companies.

As part of the aforementioned CLEAM project, further work on materials for road signs has been performed under the section "New Systems and Elements for Safety Improvement in Emergencies". This has mainly focused on materials for vertical road signs. The Laboratorio Central has also carried out a survey of the road sections in Spain that have centres for the centralized control of events that affect the safety of road users or the operation of the road (examples: Somport tunnel, M-30, Control Centre of the General Traffic Directorate in Madrid, etc.). This latter work is done with the objective of designing, as part of the CLEAM project, a road section the control of which features novelty systems for detecting and dealing with accidents.

In the field of metallic materials, the Laboratorio Central has continued performing tests for the normalization of steel reinforcement for prestressed concrete and of drawn wire for electro-welded mesh. These tests have been carried out for French, Italian and Portuguese manufacturers. Also in an international round testsphere, tests have been performed for the comparison of Ecuadorian high-ductility corrugated steel.

Within the scope of the AENOR Certificate, a number of tests on concrete reinforcement bars and prestressing cables have been performed for the Certification Committee CTC-017 Steel Products for Concrete. The tested materials have included billet wire for meshes and prestressing tendons, electrowelded mesh and prestressing cables. Steel structural elements, such as hollow tubes, have been

tested for the Certification Committee CTC-036, and other tests have been performed for the Certification Committee CTC-046 Steel Sections, Bars and Plates for Structural Use.

In the field of forensic engineering on metals, the Laboratorio Central has performed a number of surveys, including the analysis of the plausible causes for the oil spill at the oil pipeline of the Refinery of Huelva, commissioned by the Dirección General de la Marina Mercante (DGMM, General Directorate of the Merchant Navy).

QUALITY SYSTEMS

In relation to the quality system (UNE-EN ISO/IEC 17025:2005), the ENAC accreditation has been renewed for all previously accredited tests. Furthermore, the range of accredited tests in the fields of vertical road signs and metallic materials has been notoriously increased, now including the chemical analysis of steel and prestressing strand corrosion under tension. The Laboratorio Central de Estructuras y Materiales is currently accredited for testing metallic materials for reinforcement and construction, as well as materials for vertical road signs.

The Laboratorio Central takes part in the drafting of new technical guidelines and regulations, both in the field of structures and in the field of construction materials. Throughout 2009 it has actively participated in a large number of standardization committees, Spanish as well as European, and has collaborated in various inter-ministry commissions dealing with construction materials. The Laboratorio has started working on an Agreement with the Secretaría General Técnical (Technical General Secretariat) of the Ministerio de Fomento for coordinating the development of a series of documents to provide basic technical support, thus completing the Spanish technical regulations for the design and construction of structures.

Furthermore, the Agreement covers the harmonization of various codes and the coordination of the preparation of new regulations, such as the Composite Structures Code.

The Ministerio de Ciencia e Innovación (Ministry of Science) commissioned the monitoring of certain R&D projects that were originally funded by the Ministerio de Fomento, but that are currently managed by the new Ministry.

The total number of reports issued throughout 2009 for conventions and agreements was 112, having developed a total of 345 investigations for various companies. Each of these tasks projects has included a set number of more basic tests which prices are officially regulated. sometidos a precios públicos.

Concerning the expansion and improvement of the Laboratory Equipment, new installations have been set up for testing corrosion under tension and hydrogen embrittlement, the latter using the method of attack by ammonium thiocyanate solution.

The Fatigue Room at the Julián Camarillo street facilities complex has been renovated, and a new Resonant Fatigue Testing Machine has been installedpurchased.

LEFT
Cut through a sample of recycled-aggregate concrete.

RIGHT
Decay of concrete in dams.

BELOW
Concrete in marine environment.

MONITORING OF SYNTHETIC GEO-MEMBRANES IN DAM WATERPROOFING

INTRODUCTION

In 1989 the Centro de Estudios y Experimentación de Obras Públicas (CEDEX) started a long collaboration process with the Autonomic Community of Canarias for the study of waterproofing membranes used in reservoirs. The Administrative Organization with responsibility in this field within the said Autonomic Community was, back then, Balsas del Norte de Tenerife (BALNORTE, Reservoirs of Northern Tenerife). The membranes under study were made exclusively by a single synthetic material: plasticized poly(vinyl chloride). As time went by, and due to changes in the Administration, the aforementioned organization became Balsas de Tenerife (BALTEN, Tenerife Reservoirs), and the previously single synthetic material under study was faced with a broad range of materials that rendered it less important and became fierce competition in the market.

A number of years later, the Cabildo Insular de La Palma (District Council of La Palma) joined the synthetic geo-membrane monitoring project through its Consejo Insular de Aguas (Water Council).

Fourteen years ago, the DGA was in turn interested in the project, and the work that was initially limited to two of the Canary islands, became a regular monitoring of all installations throughout the whole of Spain.

The objective of this work was to verify the suitability of the synthetic geo-membranes used in the waterproofing of hydraulic infrastructure, as well as surveying their state of conservation at a particular moment in order to carry out repairs or replacements were it necessary to avoid material or human losses.

The aim of this article is to inform about the work that has been carried out on this issue, including tests and the most significant results.

RESERVOIRS

The geo-membranes of approximately 150 reservoirs included in the agreements signed with the aforementioned organizations are the subject of this study and monitoring. Besides the reservoirs, the polymeric geo-synthetic barriers for the few Spanish dams that feature this type of protection have also been studied. It is worth mentioning a small dam waterproofed using plasticized poly(vinyl chloride), the dam of Acanabre in the island of La Gomera, and other slightly larger dams, such as that of Odiel-Perejil (Aracena, Huelva), where the waterproofing membrane is made of chloride polyethylene, and that of Puente Porto (Garlene, Zamora), waterproofed with thermoplastic polyolefin (Fig. 1).

The water in these reservoirs is used, mainly, for irrigation, although on certain occasions it can have other uses, such as human consumption in the cases of Campotéjar, Cirauqui, La Casa de las Chumberas, La Contraviesa, Torrealta-1 and Torrealta-2.

Some of them store treated water, such as the reservoirs of Capdepera, El Saltadero, Es Mercadal, Inca, Peguera, Pilar de la Horadada, Pla de Sant Jordi, Sa Rota, San Isidro and Valle de San Lorenzo.

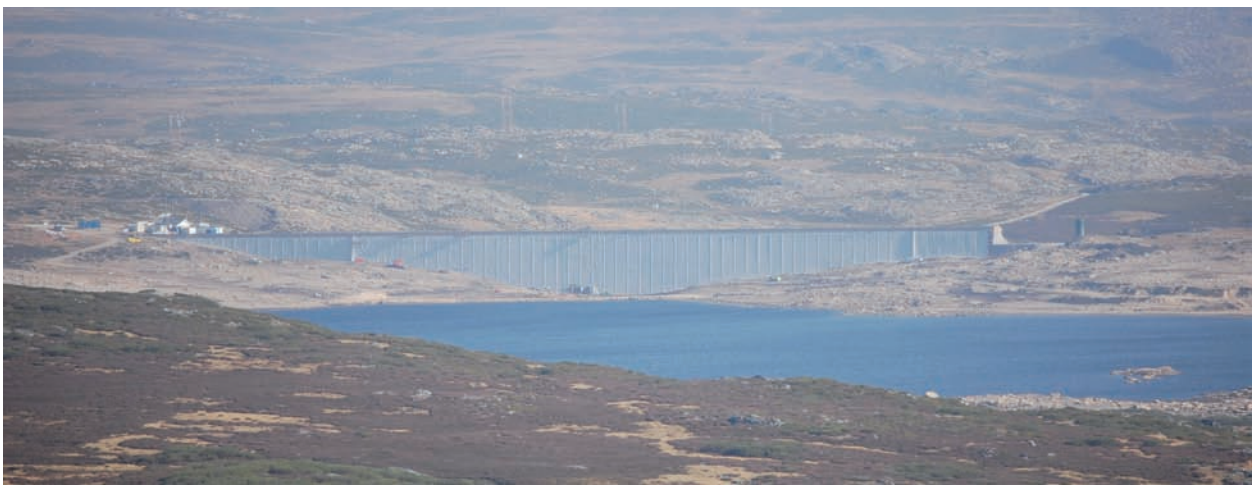


Fig. 1.- Puente Porto dam, waterproofed with a thermoplastic polyolefin geomembrane.

Fig. 2.- Hondón de las Nieves reservoir, in the province of Alicante, waterproofed in 1990 with PVC-P.

Furthermore, the CEDEX and BALTEN have designed an experimental field located in the south of the island of Tenerife. For the last fifteen years, novelty products have been tested there, as well as other products from commercial firms newly established in Spain.

GEOMEMBRANES

The synthetic geomembranes, currently called polymeric geosynthetic barriers (GBR-P) by European regulations, being studied cover the range of possible materials used in this technology area, not only in our country, but worldwide. Nevertheless, the materials that are more broadly monitored, for they are the most widely used, are plasticized poly(vinyl chloride) (Fig. 2), high density polyethylene and dienic ethylene-propylene monomer terpolymer rubber.

Three types of materials were analysed:

Type 1:
- Ethylene copolymer / vinyl acetate (EVA/C)
- Plasticized poly(vinyl chloride) with glass fibre reinforcement (PVC-P/fv)
- Homogeneous plasticized poly(vinyl chloride) (PVC-P/h)
- Plasticized poly(vinyl chloride) reinforced with synthetic fibers (PVC-P/hs)
- Chloride polyethylene (CPE)
- High density polyethylene (PEAD)
- Low density polyethylene (PEBD)
- Medium density polyethylene (PEMD)
- Very low density polyethylene (PEMBD)
- Thermoplastic polyolefins (TPO)
- Polypropylene (PP)

Type 2:
- Chlorosulfonated Polyethylene (CSM)

Type 3:
- Butyl rubber (IIR)
- Ethylene/propylene/dienic monomer terpolymer rubber (EPDM)
- Elastomeric polyolefins (POE)

Some geomembranes are waterproofing, such as those installed in the reservoirs of Buen Paso, La Cruz Santa, Montaña de Taco, La Tabona, Sa Rota, San Antonio, Torrealta-1 and Valle Molina. In all these cases, the original sheet was made of plasticized poly(vinyl chloride); the replaced membrane was also PVC-P, except for the cases of Buen Paso and Sa Rota, where a PEAD membrane was used, and Torrealta-1, where the membrane was EPDM.

The original sheets of various reservoirs were tested. These tests will serve as reference for later monitoring, as well as for confirming its compliance with in-force regulations. Likewise, the polymeric geosynthetic barriers of a number of dams, including the Matavacas, Acanabre and Puente Porto diversion dams, have also been tested.

Furthermore, the geotextiles in the waterproofing systems of newly-constructed dams were tested.

TECHNICAL VISIT AND SAMPLING

The CEDEX has carried out a number of technical visits to the reservoirs and the relevant material was collected.
The material samples were taken from specific zones prepared for sampling, if available, (Fig. 3). For the cases where these zones were not built during the installation of the geomembrane, the samples were taken directly from the waterproofing membrane. In those reservoirs where the waterproofing sheet had been in place for around twenty years, samples were taken from the four cardinal orientations (north, south, east and west), both on the upper level of the banks and close to the water.

MONITORING

The initial tests have been carried out according to the instructions given in the regulations in-force.

In periodic monitoring, since we are dealing with destructive tests, the smallest possible amount of material is taken in order to not damage the waterproofing system, but so that the quantity is enough for clearly observing the condition of the material at the time when the sample is taken.

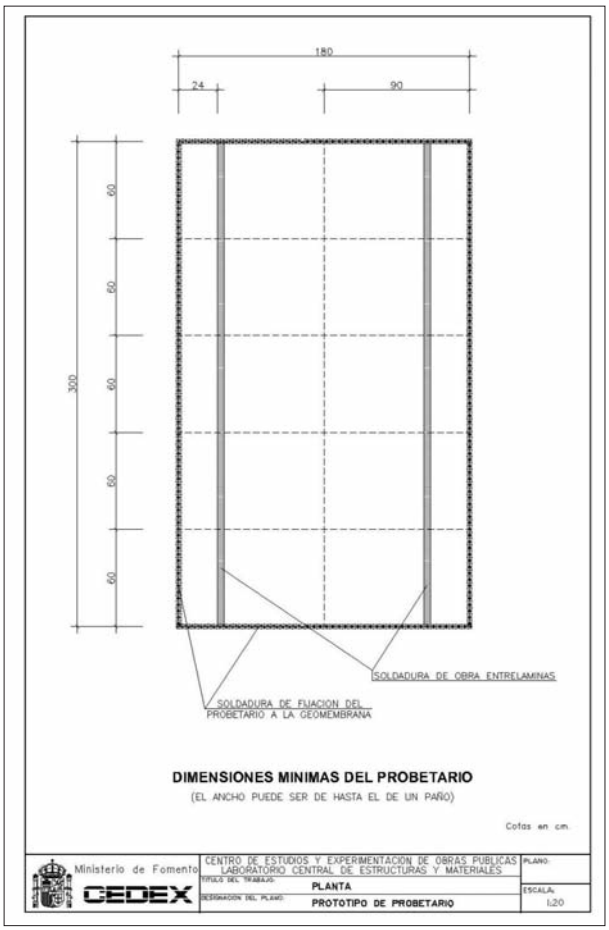


Fig. 3.- Standard sampling zone.

Thus, fewer tests are performed:
- Tension strength
- Plasticizer content (PVC-P)
- Low temperature folding
- Shore A strength (in rubber) and shore D strength (in PEAD)
- Thickness
- Scanning electronic microscopy
- Optical microscopy
- Carbon black and corresponding dispersion (PEAD)
- Resistance against perforation/puncture (static impact)
- Tear resistance (PEAD and Puente Porto dam)
- Resistance to peeling welding
- Resistance to traction welding
- Mechanical resistance to impact

Figure 4 shows the polymeric geosynthetic barrier made of plasticized poly(vinyl chloride) installed in the Manuel Remón reservoir in the island of La Palma.

CONCLUSIONS

1.- Poly(vinyl chloride) is a rigid material that needs to be made flexible in order to use it as a polymeric geosynthetic barrier (GBR-P). Commonly, this process is done by external plasticization, that is, by adding certain plasticizing additives, generally heavy molecular weight esters. The problem with this process is that this kind of geomembrane loses these plasticizing products throughout time and thus the sheets become more rigid and undergo notable decay.

2.- In the case of materials reinforced using synthetic fibers, tension strength and elongation are a function of the fiber used in the reinforcement. Their variation with time is small, for the synthetic thread is protected by the resin and shelters it from solar radiation. Besides the two aforementioned mechanic properties, other properties are measured in the case of homogeneous materials, such as the load for a 300% strain in rubber, and the strain and load at the yield point for polyethylene. For all homogeneous sheets, strain at the break point decreases with time. This decrease is particularly important for elastomers.

3.- Most of the tested samples have passed the low temperature folding test. After 5 hours in a fridge at a particular temperature according to the nature of the macromolecular material, and later being folded by 180° for 3 seconds in each direction, no cracks can be observed along

Fig. 4.- Manuel Remón reservoir in Puntallana (La Palma), waterproofed with PVC-P.

the pleat. Only PVC-P samples taken from membranes that have been installed for many years did not pass the test. The materials that presented better properties in this behaviour were polyethylenes and polypropylenes; on the opposite end of the spectrum, we find plasticized poly(vinyl chlorides).

4.- Every one of the samples passed the Mechanical resistance to impact test. After hurling the hammer, 0.5 kg in weight with 12.7 mm diameter semispherical end, from a height of 500 mm, the sheet does not suffer from perforation at the impact area, as proven by a later waterproofing test. The height used for testing rubbers is reduced to 300 mm. Nonetheless, the vulcanization experienced by this material with time enables it to withstand the test even from a height of 500 mm. Therefore, from the point of view of the dynamic impact, we may say that the best performance is found in high density polyethylene, and the worst on rubber.

5.- The best behaviour of the geomembranes tested for static puncture was found on vinyl ethylene-acetate copolymer, rubber, polypropylene and polyolefin. Conversely, the worst behaviour corresponded to high density polyethylene and chlorosulfonated polyethylene. Furthermore, homogeneous materials perform better than reinforced ones.

6.- Tear strength tested on polymer geosynthetic barriers made of polyethylene and on thermoplastic polyolefin from the Puente Porto dam presents adequate values for this type of waterproofing sheet. The values in polyethylene are appropriate, but not so in rubber.

7.- The photographs taken during the carbon black dispersion test show that this dispersion is correct in all cases. In a scale of 1 to 7, the value obtained was below 3 (the lower the value, the better the dispersion of the additive).
8.- When measuring the Resistance to traction welding, all samples break near the joint, but not through the weld itself. When it is required to quantify the condition of the joint between panels, and if the dimensions of the joint are enough, the test is done using the peeling welding-procedure. The highest values correspond to high density polyethylene, and the lowest to rubber.

9.- Both optical reflective microscopy (MOR) and scanning electronic microscopy (MEB) show an internal face that is generally a homogeneous and uniform surface. It commonly features certain superficial damage, mostly micropores. The external face suffers decay with time due to continuous exposure to solar ultraviolet radiations. This decay is manifested through microcracks, craters and superficial cracking.

10.- The obtained results have served as the basis for drafting the relevant chapters of the *Manual para el Diseño, Construcción, Explotación y Mantenimiento de Balsas (Manual for reservoir design, construction, operation and maintenance)* of the MARM, that is the chapters on waterproofing using synthetic geomembranes of different nature. The manual is currently about to be printed .

LABORATORIO DE GEOTECNIA

Within the CEDEX, the Laboratorio de Geotecnia is specialized in foundations, earth structures, soil and rock mechanics and, in general, all engineering activities related to the ground. The objectives of the Laboratorio de Geotecnia set for 2009 included, on the one hand, upkeeping or increasing the work in the field of non-concurrent specialized technical assistance, and, on the other hand, an ambitious plan for technological enrichment by investing in equipment and applied research. The former objective would be achieved by providing assistance on geotechnical issues mainly to the Directorates of the Ministerio de Fomento (Ministry of Transport) and the Ministerio de Medio Ambiente, Medio Rural y Marino (MARM, Ministry of the Environment), but also to Directorates in other ministries, autonomic regions, public entities, associations and companies.

The Laboratorio de Geotecnia has considered to be essential its participation in R&D&i European themed networks in the field of geotechnical science in order to strengthen its technological capacity and to carry out technical assistance projects. Therefore, in the field of railway line geotechnics, over the last three years the Laboratorio has taken part, in conjunction with ADIF (Spanish Administrator of Railway Infrastructure), in the integrated project INNOTRACK, included in the 6th Framework Programme of the EC. The objective of this project has been that of contributing to the reduction of railway track life cycle cost in Europe. A total of 11 administrators of railway infrastructure, 10 research centres and 5 industrial companies have participated in the project. The final reports corresponding to the two activities developed by ADIF and CEDEX have been issued. One of the activities focused on establishing stiffness variations in transition zones between viaducts and platforms in high speed lines; the other activity dealt with techniques for improving the ground conditions between masonry structures and platforms in standard railway lines. On the 4th and 5th of February 2009, the meetings of the two relevant working groups were held in Madrid, and the results of both activities were presented in a conference organised by the International Union of Railways (UIC) held in Paris on the 15th of October.

Through the Laboratorio de Geotecnia, the CEDEX takes part in the European Network ALERT-Geomaterials. The annual activities for 2009 associated to this network have been carried out, including the meeting held in Aussois (Francia), where the annual meeting of the board of directors has also been held; the annual conference and the graduate course. Furthermore, there have been a number of collaborations with universities, most of them established through the ALERT Network, including the University of Salermo, the Polytechnic University of Milan, the Polytechnic University of Turin and the University of Hohai (Nanking, China). These collaborations have yielded associated research activities.

The Laboratorio de Geotecnia has proceeded with the participation in the European Large Ge-

Landslides and collapses at the bank on the beach of Arealonga, Foz (Lugo), caused by a storm. Study of the viability of the promenade under construction.

TOP
Study of the instabilities on the service road of the Siles dam (Jaen) under construction.

BOTTOM
Studies for the survey of the foundations of the Villalba de los Barros dam (Badajoz), currently under construction.

otechnical Institutes Platform (ELGIP). The objectives of the Platform include the promotion of research, development and innovation in the field of geotechnics, in particular within the European countries. Throughout 2008, the Board of Directors of ELGIP held two meetings. Two further meetings were organized by YELGIP, the division of ELGIP run by young geotechnical experts. One of the latter meetings was held in the CEDEX's Laboratorio de Geotecnia, in April, coinciding with the CEDEX holding the rotating presidency of this working group. In 2009, effort has been put into renewing the main objectives, as well as the corporate image, of the platform. Further effort has been put into its promotion and broadcasting in society, in the relevant field of professionals, the scientific and technical community and in the European institutions taking part in the 7th Framework Programme of the European Commission. Additionally, in 2009 the YELGIP has developed a risk analysis of geotechnical works. This work will probably finish in 2010 with a conference on the subject.

As far as the 7th Framework Programme is concerned, the Laboratorio de Geotecnia has taken part in a number of candidacies for its third call. One example is the RIVAS integrated project, in conjunction with 26 other partners. The objective of this project is to develop and normalize new techniques for reducing vibrations induced on railway lines by the transit of freight trains. A further example is a candidacy in the field of dams, the WARAN project, which aims to study and develop water collection and storage systems for the countries in river Nile basin. This project has been presented in conjunction with three European and four African partners, the African partners being found on the Nile basin. The Laboratorio de Geotecnia is responsible for one of the packages of work that focuses on the design and construction of reservoirs, together with the analysis of their impact, as well as on the study of water needs in the Upper Nile, where there are dry seasons and periods of extreme drought.

With regards to national research projects, in 2009 the Ministerio de Ciencia e Innovación (Ministry of Science) has awarded a project that will benefit from the participation of the CEDEX. The selected project, called GEODYN, was presented to the 2008 call for Fundamental Research Projects of the R&D&i National Plan (2008-2011). Its aim is to develop advanced techniques for modelling the behaviour of geomaterials and geostructures subject to dynamic and cyclic loads. It is a three year coordinated project led by Manuel Pastor from the ETS de Ingenieros de Caminos, Canales y Puertos (School of Civil Engineering) of the Universidad Politécnica de Madrid (UPM). It comprises two sub-projects, one managed by Manuel Pastor of the aforementioned university school, and the other by Pablo Mira from the CEDEX.

The Laboratorio de Geotecnia has issued a total of 21 reports on technical assistance, research and technological development for the Dirección General de Carreteras (DGC, General Directorate of Roads) of the Ministerio de Fomento. The reports have covered the following projects:

Problems concerning cut slopes and natural hill sides:

- Design and monitoring of the stabilization of the 60 m high cut located around kilometre 535 of the A-2 motorway, next to Alto de la Panadella (Barcelona).
- Cut located on kilometre 418 of the A-6, in Vega de Valcarce (Leon). This cut is over 150 m high and the instability has had an important impact on the A-6 traffic.
- Stabilization measures against landslides on the A-30 through the pass of La Cadena (Murcia).
- Landslide of hill side between the AP-7 motorway and the N 332 road near Mascarat, Altea (Alicant/Alacant).
- Fixing of the instability found on the cut near Torrecilla en Cameros (La Rioja), on kilometre 292.100 of the N-111 road.
- Instability of cuts on the N-354 road (kilometres 3.801 to 4.902) in the Autonomic City of Ceuta.
- Cut on kilometre 130.000 of the A-52 motorway in A Gudiña (Ourense).

• Various cuts on the N-623 and N-622 roads in the province of Burgos.

Problems concerning fills and earth and rock embankments:
• Instability of an earth embankment located on kilometre 110.500 of the N-632 road in the Alto del Praviano, Soto del Barco (Asturias).
• Damage in various embankments between kilometres 15.300 and 19.850 of the A-7 motorway in the Rambla de Rambuchar – Castalla (Alicante/Alacant).
• Damage of the access embankment to the viaduct in kilometre 45.8 of the A-44 motorway of Sierra Nevada (Jaén).
Damage connected to foundations and underpinning, walls and tunnels:
• Analysis of the changes proposed for the construction project of the Vallirana by-pass (Barcelona), in connection with the CEDEX's proposals.
• Report on the damage observed in the tunnel of Los Yébenes on the N-401 road (Toledo).

The Laboratorio de Geotecnia has also carried out for the DGC the work for the "Continuation of the inventory of quarries for surface course aggregates", part of actuation 15 of the new Agreement. The scope of the research includes those zones of the Iberian Peninsula under the jurisdiction of the DGC, except for a Mediterranean coast region, as this area had been included in an earlier phase of the inventory developed in collaboration with the Instituto Geológico y Minero de España (Spanish Mining and Geology Institute). This Institute will again join the organizations taking part in the current phase of the inventory. The work for recording quarries and obtaining aggregate samples has already been carried out in the autonomic communities of Aragón and Galicia. The property definition tests corresponding to these regions are currently underway.

Work has been developed for ADIF under the convention for the "Realización de Trabajos de Investigación y Desarrollo Tecnológico de Interés para el ADIF y el CEDEX en el Cuatrienio 2006-2009" ("Research and Technological development activities of interest for the ADIF and for the CEDEX in the four-year period 2006-2009"). This convention envisages the development of applied research, technical assistance and technological development projects of interest for the state-owned Spanish railway system. The date of the completion of the convention was the 31st of December 2009. The tasks described in the following paragraphs have been completed, thus meeting the commitments set out under the convention. It is worth noting that the relevant field work and the analysis of new techniques for sub-ballast compaction monitoring have been carried out under the framework of this convention with the ADIF. According to the results obtained from with this work, a practical application of this R&D activity may be expected in the next few months. Furthermore, the Laboratorio de Geotecnia has perfected the system designed for obtaining data at high frequencies used in dynamic monitoring of high speed trains and the staff have been trained for using it.

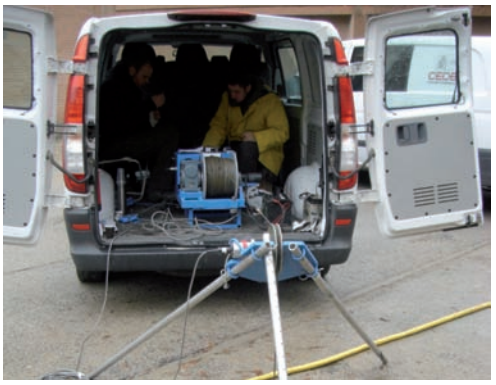
ACTUATION 1

Study of ballast and bituminous sub-ballast through full-scale accelerated tests performed at the CEDEX's premises. The following types of activities have been carried out:
• Tests on new sections using bituminous sub-ballast. Two new sections with bituminous sub-ballast have been constructed. The sections have been put in place, the instrumentation has been connected and the installation of the actuators on the central area of the testing cell has been completed.

TOP LEFT
Electric tomography on the Valcomuna dam.

TOP RIGHT
Supervision of the repair interventions on the joints between the walls of the Multipurpose wharf of the Port of Huelva. Tests: uncovered superjet-grouting columns. Test accomplished with two rotating nozzles. Tests using pressures between 200 and 600 bars and different cement consumptions.

BOTTOM
Geotechnical study for the new Containers Terminal of the Port of Cadiz.



LEFT
Drilling of experimental bore holes in calle Julián Camarillo (Madrid).

RIGHT
Tests using PS-logging on the bore holes of calle Julián Camarillo (Madrid).

The lab experts have drafted two reports compiling the results obtained in the monitoring tests performed throughout the construction of aforementioned sections and during the dismantling of the sections with granular sub-ballast that were previously installed on the premises. Fatigue tests of the central area of the testing cell commenced in the month of September. The layer of sub-ballast had a depth of 12 cm in this point. It is expected that this test is completed in early 2010.

• Maintenance of equipment. Calibration of the installation has been carried out, and a protocol for the maintenance of the equipment has been devised.

• Data treatment. A program for the systematic treatment and presentation of the test results has been developed. The program is currently being checked using the real data of the new fatigue test of the central area.

• Measurements in control sections. Two campaigns have been run on an area of the High-Speed Line Madrid-Valladolid where there are two different adjacent sections, one with granular sub-ballast, and the other with bituminous sub-ballast. The measurements were taken using temporary superficial instrumentation installed on the track. The data obtained from both sections agreed significantly well with the results from the test cell.

ACTUATION 2

Monitoring of the performance of high-speed track sections using instrumentation techniques. Work has been carried out on three high-speed sections:

• Instrumentation of part of the section Fuencarral-Canto Blanco on the high-speed railway line Madrid-Segovia-Valladolid. Superficial instrumentation was installed and a data collection campaign has been run for this section.

• Monitoring of the embankment of El Arenero between kilometres 106.280 and 106.500 of the high-speed railway line Madrid-Segovia-Valladolid for assessing the need for stabilization measures. Two data collection campaigns have been performed.

• Study of the current condition of the instrumentation and data collection on three instrumented sections on kilometre 69.5 of the High-Speed Line Madrid-Zaragoza. The section had previously been used in the SUPERTRACK project.

ACTUATION 3

Construction solutions for transition zones to optimize the change in stiffness experienced in the platform:

• The mechanical behaviour of a viaduct-platform transition zone of a high-speed railway line has been studied and compared with the mechanical behaviour of the regular line. The tests have identified the stiffness variation experienced on the track under different trains passing from the track on concrete to the track on the ground, and vice-versa, at the bridge abutment.

• The solution adopted to suppress the speed limit over an underpass in a conventional line has been validated. Measurements have been taken before and after the rehabilitation to assess the performance of the track.

• Two data analyses have been incorporated. These analyses correspond to those performed in the final reports by ADIF for the sub-project SP" of the INNOTRACK integrated project under the 6th Framework Programme.

ACTUATION 4

Check of a continuous method for assessing the degree of compaction and the degree of deformation of sub-ballast: relevant field work has been carried out in an experimental section in Santa Cruz de la Zarza (Toledo); a report has been issued interpreting the results of the field work and proposing possible alternative monitoring techniques to those currently in use.

ACTUATION 7.1

Monitoring and geotechnical advice for selecting

the construction methods to be used for the tunnel of El Regajal in the New High-Speed Railway Access to the East of Spain. The relevant tests have been performed (many of which are long tests). The Laboratorio de Geotecnia has held meetings with the members of ADIF responsible for this project in order to initiate the non-conventional post-construction instrumentation of the tunnel of El Regajal.

ACTUATION 7.2

Guidelines for the auscultation of railway platforms using georadar. Two reports have been drafted as part of this actuation: Fase 6: Auscultación con GPR del tramo Illescas-Villaluenga, Abril 2009 (Phase 6: Auscultation of the section Illescas-Villaluenga using GPR, April 2009); and Procedimiento para auscultación de plataformas ferroviarias con geo-rádar. Informe final. Octubre 2009 (Guidelines for railway platform auscultation using georadar. Final Report. October 2009).

ACTUATION 8

Analysis of the guidelines for high-speed railway platform treatment using lime. This actuation has entailed work on the following sections of a number of high-speed railway lines that are currently under design or construction: Vera-Sorbas, in the section Murcia-Almeria of the High-Speed Mediterranean Line; Tocón- Valderrubio, of the High-Speed Railway Line section Bobadilla-Granada; and Becerril de Campos-Río Cea, in the section Palencia-León of the High-Speed North-Northwest Line. Throughout the second semester of 2009, the Laboratorio de Geotecnia has planned and prepared the work to be included in the new agreement ADIF-CEDEX signed on the 22nd of December of 2009. The work lies along the lines of applied research, technical assistance and technological development in geotechnics of interest for ADIF, and will be developed throughout a period of four years.

The public entity Puertos del Estado (National Ports) holds a General Convention with the CEDEX. Within this convention, the Laboratorio de Geotecnia has provided geotechnical assistance to a number of Spanish Port Authorities who have requested this service. For the Port Authority of Alicante, the Laboratorio has drafted a report covering the preliminary analysis of the fill found at wharf no. 17, as well as the condition of the foundations of a wind parapet in the same wharf. The work done for the Port Authority of Barcelona has comprised a report compiling the results obtained from laboratory tests of samples taken from the Prat wharf. The work for the Port Authority of Cadiz has consisted of technical advice on the design project for the new Containers Terminal; a report compiling the geotechnical aspects to be taken into consideration in the design has been issued. The Port Authority of Huelva has received advice on the construction and monitoring work for the Promenade. The Laboratorio has issued a report on the shear performance of the timber piles used to support the promenade's embankment. The Port Authority of Malaga has been advised on the widening of the road and refurbishing of the access to the Eastern dike. A report analyzing the safety coefficient of the chosen solution against seismic action has been issued.

The CEDEX's Laboratorio de Geotecnia has developed the following R&D&i projects with Puertos del Estado on issues related to Marine Works Geotechnics:

- In the actuation "Deformability analysis of rip-rap to be used in bedding layers for cofferdams" the CEDEX has issued a report on the performance and deformability analysis of rip-rap bedding layers of the cofferdams in the Sur de la Cabezuela wharf (Cadiz). A study of the bedding layer of the mineral wharf in the port of Huelva is currently underway.
- In the actuation "Techniques and guidelines for the assessment, property definition and improvement of port fills", a working group has been set up. This working group comprises staff from the

Study for the geotechnical property analysis of volcanic materials.

General overview of actuators and sensors used in the fatigue test of the first platform with bituminous sub-ballast analyzed at the CEDEX's railway installation.

Inventory of quarries for surface course aggregates for the DGC. View of one of the analyzed quarries.

Laboratorio de Geotecnia, from Puertos del Estado and from Port Authorities, and its aim is to draft a document about geotechnical aspects of port fills.

• In the actuation "Guidelines for measuring geotechnical parameters in defence dykes", the initial report has been drafted. The report details basic aspects related to the geotechnical instrumentation of dykes, paying special attention to new instrumentation technologies used in this field.

• In the actuation "Guidelines for measuring geotechnical parameters on the extrados of cofferdams", the guidelines for the analysis of thrust on the extrados of cofferdams are being developed. The work also covers the analysis of thrust of cofferdams cells during their fill with dredged material.

• In the actuation "Dynamic study of cofferdams. Phase 2", an article has been drafted compiling the work carried out in Phase 1 of the study. This article is to be published for the journal Puertos. Besides, a constitutive equation for sands is being developed, based on the concept of state parameter.

The CEDEX holds a convention with the Dirección General de Sostenibilidad de la Costa del Mar (DGSCM, General Directorate of Sea Coast Sustainability). Under this convention, the Laboratorio de Geotecnia has prepared a report about the study of and proposal of corrective measures for the instabilities generated in February 2009 on the coast embankment of the Area Longa beach (Lugo).

For the Dirección General del Agua (DGA, General Directorate of Water) of the MARM, the Laboratorio de Geotecnia has provided advice on geotechnical issues and has carried out geotechnical surveys and studies under the Convention for the management of the water public domain and the operation of infrastructure. These activities, among others, have been implemented on the study of the instability of the left bank of the river Carrión through the municipality of Carrión de los Condes (Palencia); on the study of leaks in dams using geophysical techniques (Caspe II, Rialb, Santa Lucía and Valcomuna); in the deformability study of the foundations of the dam of Villalba de los Barros (Badajoz) from the results obtained from pressuremetric tests and from the numerical modelling of the dam's longitudinal section; in the geotechnics chapters drafted for the manual for reservoir design, construction, operation and maintenance; and in the analysis of the stability conditions of the service road of the Siles dam (Jaen). As part of the actuation called "Prevention of natural and infrastructure-induced water risks", the Laboratorio de Geotecnia has issued a report that includes the development of a model for hill side landslides under seismic loads and by liquefaction, and an "average point" integration algorithm for a generalized plasticity model for sands.

Furthermore, a number of reports have been written about the results of laboratory test made on samples taken from the dam embankment and basin of the Yesa dam; from the riprap of the Alcorlo dam; from the material found around the Itzoiz dam; from the riprap of the Soto-Terroba dam; and from the material to be used in the dike closing the reservoir of Cadimo (Jaen).

The Laboratorio de Geotecnia has issued another set of reports on the current geotechnical conditions of the following dams in the autonomic community of Castilla y Leon: Antoñan (Leon), Arrieta (Burgos), Encinas de Esgueva (Valladolid), Lomilla de Aguilar (Palencia), Santa Lucía de la Sierra (Avila), Tortoles de Esgueva (Valladolid) and Villagatón (Leon).

A further ongoing project commissioned by the DGA is the monitoring of the operation of the biological reactors of the second phase of the Wastewater Treatment Plant of Galindo (Bilbao), by monitoring the settlement.

In the field of Environmental Geotecnics projects, it is worth mentioning the stability study of two coal waste heaps in the municipality of Tremor de Arriba (Leon) carried out for the Foundation "Ciudad de la Energía". Another representative project is the study of the possible uses of aggregates from Construction and Demolition By-products (CDB) in railway fills.

Under a commission from the Dirección General de Calidad y Evaluación Ambiental (DGCEA, General Directorate of Environmental Quality and Control), the Laboratorio de Geotecnia is collaborating with the CEDEX's Centro de Estudios del

LEFT
Repair of the crack through the slope of 'La Escrita', on kilometre 418 of the A-6 motorway. Aerial view of the top, taken on the 2-10-09.

RIGHT
Slope of La Panadella, kilometre 535 of the A-2 motorway. Aerial view taken during the repair works, on the 15-7-09.

Transporte on the "Seguimiento y participación en el desarrollo de los trabajos de Normalización Europeos sobre el establecimiento de criterios medioambientales en la utilización de áridos en carreteras" ("Supervision of and participation in the development of European Standardization work on the stablishment of guidelines for aggregates used in roads"). As part of this project, the CEDEX is working in the committees CEN/TC 351 and AENOR-CTN 193. For the same GD, a number of actuations have been updated, including those relative to CDB, phosphogypsum, coal mining wastes, out of use tyres and flying ashes from the Catálogo de Residuos (By-Product Catalogue) published by the MARM.

It is worth noting that the chemical division of the Laboratorio de Geotecnia has been working on the definition of the polluting and dangerous materials content in furnace slag from urban solid waste (USW) incineration. Furthermore, this Laboratorio permanently collaborates with the Laboratorio Central de Estructuras y Materiales and with the Centro de Estudios de Técnicas Aplicadas on the analysis of main anions and cations present in Spanish water.

The CEDEX signed a contract with the Consejería de Obras Públicas (Department of Infrastructure) of the Autonomic Community of Canarias for the 'Estudio del comportamiento geomecánico de los piroclastos canaries de baja densidad para su aplicación en obras de carreteras' ('Study of the geomechanical performance of Canarian low-density pyroclasts for their use in road construction'). The project will take place over 24 months and is the issue of a doctorate thesis.

One further contract has been signed with the company Gorona del Viento El Hierro S.A. The aim of this project is to develop a study on 'Technical Assistance for the construction project: 'Upper deposit of the hydroelectric power plant of El Hierro''. The construction was carried out in three months. It was completed in December with the report 'Analysis of the suitability of the design implemented in the construction project for the treatment of the bottom of the upper deposit in the hydroelectric power plant of El Hierro'.

The Laboratorio de Geotecnica appointed two expert engineers to take part in the proceedings at the Court of Seville in relation to the possible pollution of the Nieblas-Posadas aquifer caused by the works at the Cobre Las Cruces mine. The expert engineers have issued two reports in response to these proceedings.

The CEDEX and Geotecnia y Cimientos, S.A. (Geocisa) have signed the convention 'Study of the pollutants diffusion through the barriers of urban dumpsites and its evolution in time'. Within the scope of this convention, the CEDEX has worked the project developed by Geocisa and the Universidad Autonoma de Madrid under the framework of the Plan Nacional de I+D (National R&D Plan). The convention's second partial report has been issued, compiling the activities carried out in 2008.

The CEDEX has also worked on the study of a permanent connection between Spain and Morocco through the Strait of Gibraltar. A two-day meeting was held at the CEDEX's premises, precisely in the CETA building, for the final evaluation of the preliminary design for the Gibraltar tunnel. The Laboratorio de Geotecnia took an active part in this meeting as one of the members of the board of experts promoted by the SECEGSA and SNED societies, from Spain and Morocco respectively.
The Laboratorio de Geotecnia has continued collaborating with AENOR, holding the Presidency and Secretary of the Spanish group of the Subcommittee SC-7 (CEN TC-250), in charge of drafting the Geotechnics Eurocode 7. The translation of Part 1 of Eurocode 7 (Geotechnics) has been completed and the draft of the National Annex is being developed. The translation of Part 2 of Eu-

LEFT
Railway track instrumentation for the work under the ADIF-CEDEX convention.

RIGHT
Detail of the railway track instrumentation for the work under the ADIF-CEDEX convention.

rocode 7 is currently underway. Both the National Annex for the application of Part 1 and the translation of Part 2 will be completed in the first semester of 2010. Furthermore, the Laboratorio de Geotecnia holds the Presidency of the Committee CTN 146, "Aggregates", in charge of drafting the UNE-EN Regulations for establishing the properties of aggregates to be used in railway ballast, rockfill for dams and port dykes, road bases and sub-bases, surface courses, concrete, mortar and light aggregates. The said committee is also responsible for drafting the UNE-EN specifications that these stone materials must meet in order to be used in each of the aforementioned elements.

The Laboratorio de Geotecnia has worked on the Convention established between the Asociación de Empresas de Técnicas Especiales del Suelo y del Subsuelo (AETESS, Association of Technical Companies Specialised in Soil and Sub-soil) and the CEDEX. This work has included the drafting of the document 'Hormigón para Cimentaciones Especiales' ('Concrete for Special Foundations'), currently being developed by a working team comprised of experts from the CEDEX and AETESS and coordinated by the Laboratorio de Geotecnia. This document will contribute to improving the quality of the construction of piles and retaining walls.

In 2009, the Laboratorio de Geotecnia has developed further the work started in 2008 for continuously updated compilation of information in the field of geothermic energy applications in construction. In line with the open-minded attitude towards geothermics, the Laboratorio de Geotecnia has engaged itself as an active member in the Plataforma Tecnológica Española de Geotermia (GEOPLAT, Spanish Technological Platform for Geothermics). This Platform was created on the 11th May 2009 and is comprised of seven working groups. The Laboratorio is a member of two of the groups: 'Geotermia somera' and 'Formación'. Furthermore, the Laboratorio has coordinated the preparation of articles for issue 156 of the magazine Civil Engineering, an issue devoted to application of geothermic energy in construction. Likewise, it has participated in the proposal for a research project for the Plan Nacional de I+D, in collaboration with the Rodio Kronsa group and the company Energesis Ingeniería. The said project aims to focus on research and experimental studies for the correct application of very-low-enthalpy geothermic energy to foundations.

The internal R&D&i project 'Convergencia de túneles en macizos viscoelastoplásticos' ('Tunnels convergence in visco-elastoplastic massifs'), started in 2006, was completed in 2009 with the presentation of a doctorate thesis by D. José Guillermo Sandoval Ocaña. The thesis, entitled 'Estudio de la convergencia por fluencia de túneles circulares en medios viscoelásticos plásticos' ('Study of circular tunnel convergence by creep in viscoelastic plastic media'), was presented on the 23rd of February at the Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos –Civil Engineering School- of the UPM and obtained top marks with a Sobresaliente Cum Laude por unanimidad. Lastly, an internal report ('Estudio sobre la convergencia de túneles en macizos viscoelastoplásticos' – Study of tunnels convergence in viscoelastoplastic massifs') has been issued, thus completing the project.

Within the internal R&D&i project 'Actualización de ensayos geofísicos aplicados a las geotecnia' ('Update of geophysical tests applied to geotechnics'), the Laboratorio has started the work for performing six geotechnical boreholes (November 2009) in the CEDEX's premises on calle Julián Camarillo in Madrid. The objectives behind this activity (boreholes SIG-1 to SIG-6) are: Having well documented and executed boreholes to be used for a long-standing testing installation for tuning and optimizing geophysical equipment and techniques; using the boreholes, during the drilling and afterwards, to tune geotechnical equipment; proposing laboratory techniques for testing the samples obtained from the

boreholes; setting up a training school for borehole drilling to teach the younger staff, and illustrate the theory lessons given to the students of the Geotechnics Master; increase the scientific and geotechnical knowledge about the soil in Madrid, as well as drilling methods and sample extraction.

The Permanent Technical Service for Laboratory Geotechnical Tests has been engaged in the acquisition and tuning of the following equipment: screening equipment for large particles, X-ray fluorescence equipment , equipment for sample analysis using X-ray diffraction, mill for grinding samples and automatic compacting machine for Proctor y CBR tests. The Service has also updated the pressure systems of the triaxial test room and has modernized the pressure system and the data obtaining system of the equipment for large-dimensiondirect shear tests.

The Laboratorio de Geotecnia has worked on broadcasting and promotion of R&D&i activities. In particular, throughout 2009 it has organized the following conferences and events in the CEDEX:

- In conjunction with the Sociedad Española de Mecánica de Rocas (SEMR, Spanish Society of Rock Mechanics), the conferences about Tunnels under Difficult Geotechnical condition (Túneles en Condiciones Difíciles), attended by over 150 people, was held on the 22nd of April.
- The conference for the presentation of the Manual for Reservoir Design, Construction, Operation and Maintenance was held on the 18th of May. This Conference was organised in conjunction with the Comité Nacional Español de Grandes Presas (CNEGP, Spanish National Committee for Large Dams) and with the collaboration of the Asociación Técnica Española de Balsas y Pequeñas Presas (ATEBA, Spanish Reservoirs and Small Dams Technical Association). The Conference focused on explaining the most important aspects covered by the recently published Manual.
- In collaboration with the Universidad Politécnica de Cataluña, a conference about 'Ensayos de penetración estática en el proyecto geotécnico' ('Static penetration tests in geotechnical projects') was held in the CETA's conference hall on the 2nd of June.
- In conjunction with the Sociedad Española de Mecánica de Suelos e Ingeniería Geotécnica (SEMSIG, Spanish Society of Soil Mechanics and Geotechnical Engineering), the 3rd Spanish-Portuguese Conference on Geotechnics of Railway Infrastructures was organised and held on the 25th and 26th of June. Approximately 200 participants from both countries, as well as from other Spanish or Portuguese speaking countries attended the Conference.
- The 1st Seminar of Cooperation CEDEX-BAM with the Bundesanstalt für Materilforschung und –prüfung (Federal Instute for Research and Testing of Materials, Berlin) took place on the 7th and 8th of July.

Furthermore, the CEDEX's Laboratorio de Geotecnia directed and managed the Masters on Soil Mechanics and Geotechnical Engineering, as done over the last 12 years. Notable changes were introduced this year, as it has been converted into an official Master Degree of the Universidad Politécnica de Madrid. This has required the introduction of a Masters' thesis, extending the duration of the course to 34 weeks (instead of the 21 weeks of previous years). The courses started on the 2nd of February and the full programme was completed on the 26th of June, covering a total of 530 hours, including lectures (500 hours) and technical visits (30 hours). The students then worked on their theses during the months of July and August, and the first two weeks of September. The theses were presented on the 21st and 23rd of September. A total of 57 lecturers from the CEDEX, from different universities or from private companies have participated in the course. In the 2009 edition, the Masters was read by 28 students from 11 countries.

New X-ray fluorescence equipment, purchased in 2009.

MEASURING TECHNIQUES TO ASSESS THE MECHANICAL PERFORMANCE OF RAILWAY TRACKS

The CEDEX's Laboratorio de Geotecnia has recently perfected a series of techniques for measuring a range of parameters to define the mechanical performance of railway tracks. These techniques are applicable to conventional and high speed railways, as well as to the installation currently available at the CEDEX for testing full-scale railway track real cross-sections.

At present, the CEDEX is working on instrumented high-speed railway cross-sections in three locations:

• Section Valdestillas-Río Duero on the high-speed railway line Madrid-Segovia-Valladolid. Two cross-sections through the railway tracks have been instrumented. One section is set on bituminous sub-ballast, on kilometre 6.110; the other has granular sub-ballast and is found on kilometre 6.330. The performance of instrumented cross-sections with bituminous sub-ballast in comparison with granular sub-ballast will be studied using the results obtained from these cross-sections, together with the results from the instrumented cross-sections set up in the CEDEX's installation for scale 1:1 tests.

Figure 1. Vertical position of one of the two extensiometric bands used for finding the maximum tangential stress on the cross-section of a rail.

• Three cross-sections on kilometre 69.500 of the high-speed railway line Madrid-Zaragoza-Barcelona-French Border, section Madrid-Zaragoza. These cross-sections are 75 m apart from each other, on three different locations that affect the railway platform: a land cut, a 4 m high embankment and an 8 m high embankment.

• Kilometre 103.280 of the section Fuencarral-Cantoblanco of the high-speed railway line Madrid-Valladolid. A cross-section of the railway track has been instrumented where the track passes through a 10 m high embankment.

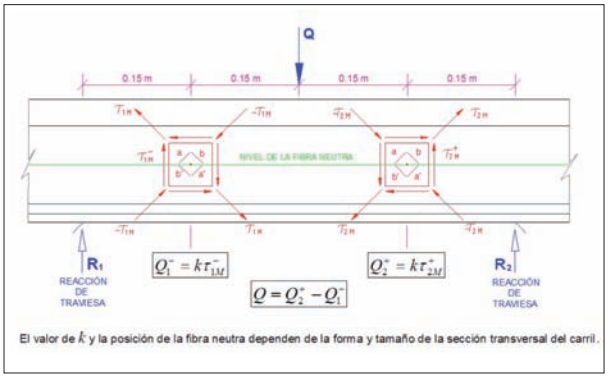


Figure 2. Scheme used for attaching the extensiometric bands on a span of track between two consecutive sleepers.

The subterranean instrumentation installed consists on pressure cells, Linear Variable Differential Transformers (LVDT) and humidity and temperature sensors. Superficial instrumentation comprises extensiometric bands stacked to the rail for measuring dynamic loads, potentiometers for measuring the relative displacement between rail and the sleeper, geophones and accelerometers, placed both on the sleeper and on the rail, and laser motion detectors for absolute movement of the rails. All these sensors are read at a rate of 10 000 values per second.

Although many of these sensors provide data that can easily be converted into engineering variables, in other cases it has been necessary to implement an initial analysis procedure, such as the case for the measurement of absolute vertical movement of the rails obtained through geophones and the loads generated by the passing of trains on a real track and by the actuators systems used in the test cell to simulate the passing of trains at different speeds.

The CEDEX's Laboratorio de Geotecnia has recently perfected a range of procedures for measuring the latter two variables on conventional and high-speed lines, as well as on the installation currently available at the CEDEX's premises for full cross-sections of real railway tracks at a 1:1 scale, that is the absolute vertical movement of the rails and the loads induced on the track by the passing of trains on a real track, or by the actuators system used in the test cell to simulate the passing of trains at different speeds.

The calculation of the loads induced on any single point of the track by the passing of the wheels of a real train, or by the system of actuators available at the CEDEX's premises, is based on the measurement of the maximum

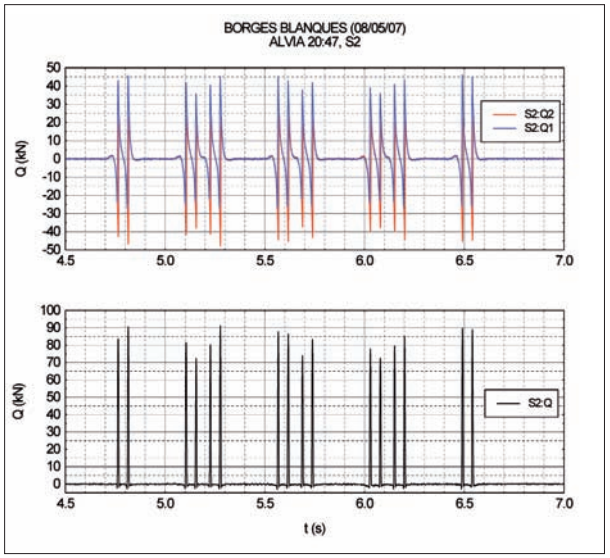


Figure 3. Load history Q per wheel obtained subtracting the shear stress histories Q2 and Q1 generated by an Alvia train at 200 km/h on a high-speed rail track span.

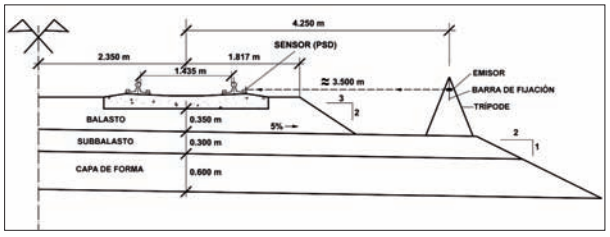


Figure 4. Scheme showing the position of sensors installed on tracks to directly measure the absolute deflections of the rail.

shear stresses that the said forces produce on the cross-section of the rail. To achieve this, 2 extensiometric bands of the type shown in Figure 1 are used. Each band is comprised of two networks of strain-gauges perpendicular to each other. They are placed so that when the band is stuck vertically to the web of the rail, the networks are at a 45° angle to the longitudinal axis of the rail. Therefore, by sticking both bands vertically to the same side of the rail, one above the neutral fibre and one below, the four networks of strain gauges are properly oriented for the purpose of the test. Once the networks are connected among them forming a Wheatstone bridge, the deformations of the rails can be obtained, expressed as strain ($\mu\varepsilon$). Then, by applying Elasticity theory, using an elastic modulus E = 0.21 TN/m^2 and a Poisson coefficient γ = 0.3, it is possible to calculate the vertical shear stress on the neutral axis (τmax) in the cross-section. Multiplying the value of τmax by a coefficient that incorporates, together with the thickness of the neutral fibre, the moment of inertia and the static moment of the rail cross-section, it is possible to obtain the vertical shear force (Qi) generated by the external load at the point of the track where the two extensiometric bands are fixed.

Figure 5. Receptor (PSD) for horizontal laser rays (right) and 2 Hz geophone (left) attached to the base of the rail.

Figure 2 shows the operative scheme used for calculating the load Q generated on the rail by the passing of a train wheel. This can finally be achieved by subtracting the history of the shear forces Qi, calculated as described above, on two points of a rail span between two consecutive sleepers. Bearing in mind that the span between sleepers is 0.60 m long, it has been considered convenient to position the points 0.30 m apart, each 0.15 m away from the midspan.

As an illustrative example of the load history that can be obtained at a point of a track using this technique, two load histories have been represented at the top of Figure 3. Shear forces Q2 and Q1 have been generated by and Alvia train moving at 200 km/h on a rail span instrumented according to the scheme in Figure 2. The instrumented span is located on the high-speed line between Lleida and Tarragona. At the lower part of Figure 3, the load history Q is shown. This load has been generated on an instrumented rail by the passing of the wheels of the aforementioned train. This load history has been obtained by subtracting Q1 from Q2.

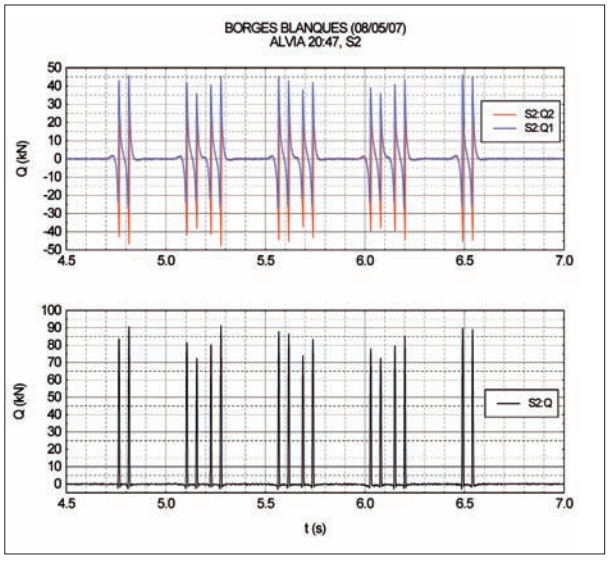


Figure 6. Response curves for the selected 2 Hz geophone.

Similarly, but fixing the two extensiometric bands on either side of a sleeper, it is possible to obtain the history of the resultant of the forces that act on the sleeper as a train passes. The history of the reactions on the sleeper can thus be calculated, as the history generated by each wheel is known thanks to the aforementioned procedure.

The absolute vertical movements, or absolute deflexion (δ) of the rail can be found immediately by using, as shown on Figure 4, a 1D laser photo-voltaic system comprised of a transmitter and (T) and a receptor (PSD, Position Sensitive Detector). Once the transmitter is installed on a fixed base at a certain distance from the track, it emits a horizontal ray of light of constant position in space. This ray serves as reference level to measure the vertical displacements experienced by the receptor placed at the base of the rail (see Figure 5). The equipment used has a resolution of 0.001 mm and an accuracy of ± 0.01 mm for a maximum distance of 6 m between transmitter and receptor. Both the transmitter and the receptor are provided with the suitable pieces to be easily attached to vertical bars of 20 mm diameter (the transmitter) and to the base of the rail (the receptor). To calibrate the laser system in the laboratory, a mechanical precision wheel is used with transmitter and receptor rotated by 90°. Once the receptor is fixed to the wheel, the calibration is done moving it horizontally while the vertical sign emitted by the transmitter remains steady. The transmitter has previously been placed at a certain distance from the wheel.

In order to perfect a system for obtaining the deflections of the rail without the need to install or build at a certain distance from the track a fixed base for reference, a small 2 Hz geophone type L-22E MARK has been selected. The small dimensions (60.3 mm diameter and 50.8 mm height) and weight (0.425 kg) of this device make it a suitable instrument to be installed on the base of a rail, substituting the laser receptor (PSD) (see Figure 5). In comparison with other type of equally small sensors, for example accelerometers, the geophone has the advantage of not requiring external electricity to work and of enabling the easy correction of the base line of integrated signals.

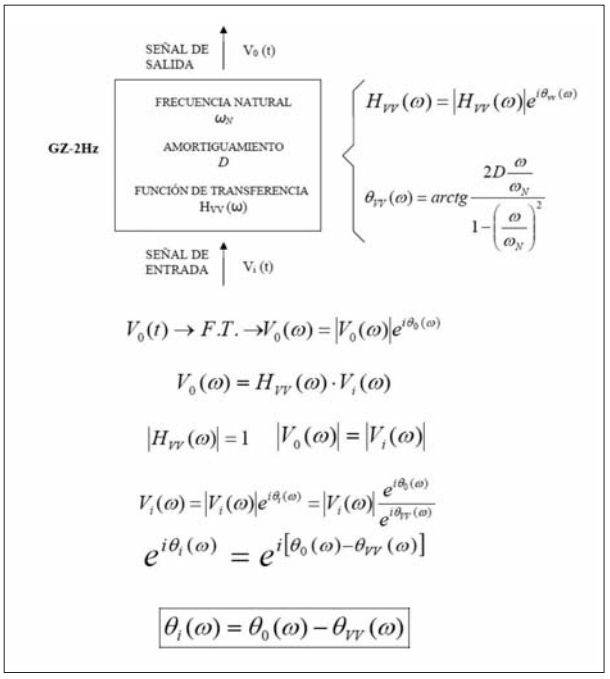


Figure 7. Operation scheme for correcting the necessary phases of the signal recorded by the 2 Hz geophone.

This sensor represents a dumped system of a single degree of freedom. Therefore, it modifies the signals it perceives according to its dynamic properties (ωN = 2.11 Hz; D = 0.676). The components of the transfer function that incorporated the aforementioned properties are given in Figure 6. In this figure it is possible to see how the selected 2 Hz geophone hardly modifies the amplitude of the signal it received for frequencies above its natural frequency (ωN). On the contrary, the geophone clearly modifies the phases of the signal for frequencies between 0 and 20 Hz.

Therefore, before integrating the signals recorded by the geophone to obtain the deflection on the rail, it has been considered necessary to modify the phases of the harmonics that make up the signals. This process is done following the scheme given in Figure 7. As shown in the Figure, the

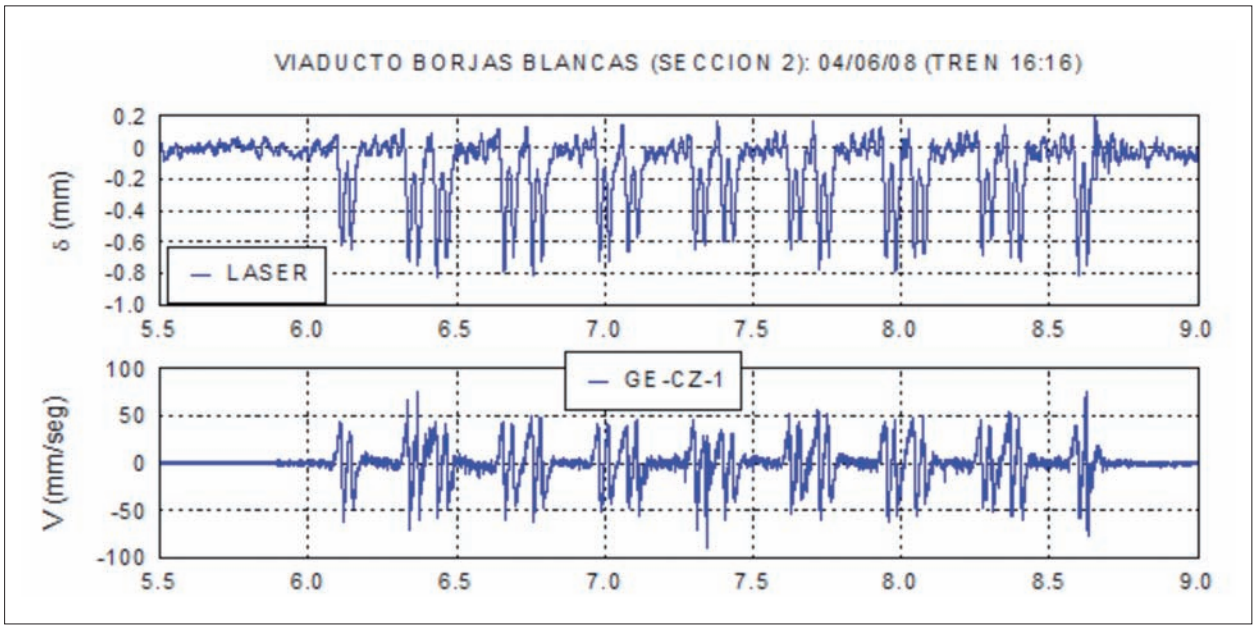


Figure 8. Deflection and velocity histories obtained at a point of the high-speed line Madrid-Barcelona during the passing of an S-103 train at 300 km/h .

signal (input) received by the sensor is corrected in the domain of the frequencies by previously calculating its Fourier Transform. The Inverse Fourier Transform of the corrected signal provides the history of the velocity. Once this is integrated, the history of the deflections is obtained. In order to correct the base line of the integrated signal, should this be required, it is recommended to use a high-pass filter, with 0 Hz roll off and 0.5 Hz cut off. The resultant signal obtained by this method should be expected to have a slightly smaller amplitude than is required. This happens because the scheme in Figure 7 does not correct the modulus of the signal registered by the sensor.

In order to illustrate the results obtained using this technique, Figure 8 shows the rail deflection and velocity histories recorded under the passing of a train of the series S-103 at 300 km/h through a point of the high-speed railway line Madrid-Barcelona. The devices used were a laser system (for deflections) and a 2 Hz geophone (for velocities), and they were positioned next to each other, as can be seen in Figure 5.

On the graph given at the top of Figure 9, the deflections history registered using the laser system as the first bogie of the train passed has been highlighted. The graph in the middle of the Figure shows the results of the integration of the signal recorded by the 2 Hz geophone as the bogie passed. No previous corrections have been done for the harmonic phases. Finally, the lower graph of the Figure gives the result of integrating the said history, having previously corrected the harmonic phases in the frequency domain. Comparing the two lower graphs in Figure 9 it may be concluded that, in order to obtain a good estimate of the total deflection history generated on the track by the passing of trains, it is sufficient to correct the harmonic phases of the signal registered by the 2 Hz geophone selected for the analysis.

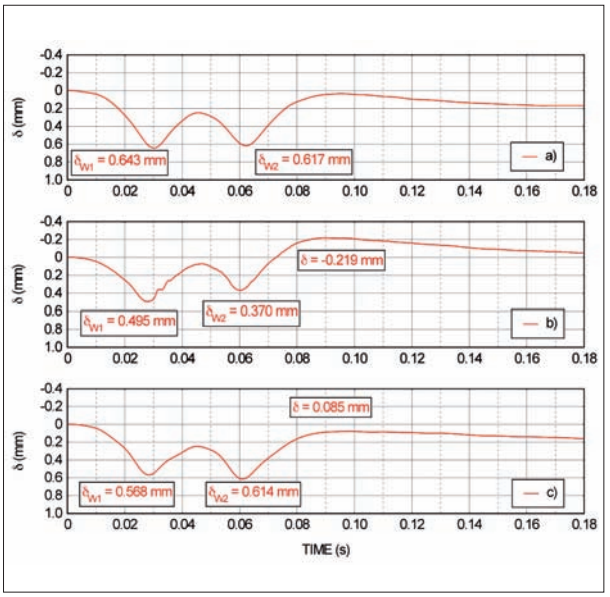
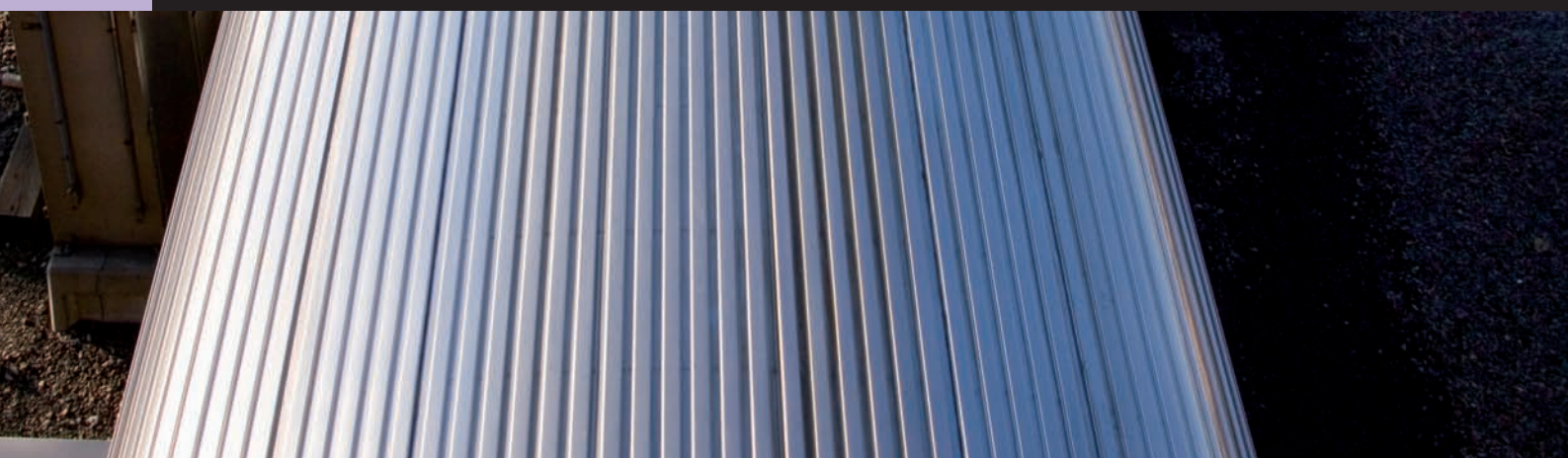


Figure 9. Absolute deflections of the track obtained using: a) a laser ray system; b) with no correction of the phases of the signal received by a 2 Hz geophone; and c) previously correcting the phases of the signal received by the geophone.

LABORATORIO DE
INTEROPERABILIDAD FERROVIARIA



The work of the Laboratorio de Interoperabilidad Ferroviaria (LIF) in the international sphere is focused on the involvement of the Laboratorio de Eurocabina in the test guidelines for the certification of the ERTMS Onboard constituents. The final guidelines developed were incorporated into the European Directive 2008/57/CE for Railway's Interoperability , after being approved by the Member States of the European Union. The technical guidelines for the version 2.3.0 "d" of the System Requirements Specification is being used on the Spanish railway scope, in particular on short-distance trains in Madrid, and on the high-speed railway lines Madrid-Valencia/Albacete and Barcelona-French Border.

Efforts in the European sphere have yielded three vital outcomes for the future of the Laboratorio:

• A better thought through set of guidelines for performing tests has been developed. These new guidelines assure a better interoperability between the generic constituents of ERTMS that are certified under the scope of this regulation.

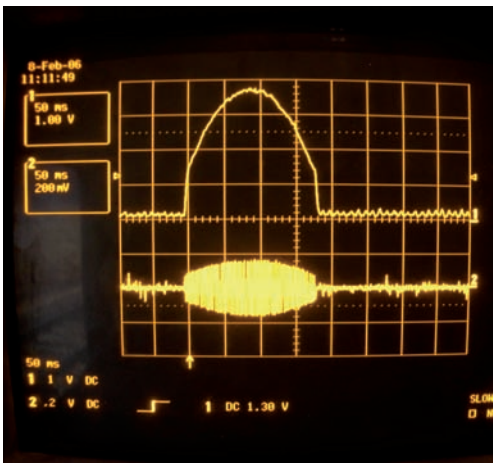
• Within the national scope, the Laboratorio is a valuable asset in the implementation of commercial railway projects. Useful tools have been developed for their application along this line of work. Particularly worthy of mention is the Test Sequences Debugger a kind of reference model for the Onboard ETCS Subsystem, the applications of which are commented below.

• The Laboratorio has worked in partnership with the German DLR, Multitel (Mons University) in Belgium, RINA Notified Body based in Genoa (Italy) and INECO-TIFSA, deepening the specialisation and building up the mutual confidence in the group of laboratories.

The work performed at a European level has been culminated, at the end of the year, with the commissioning of a project by the European Railway Agency. The project, ERA/2009/ERTMS FWC/S-04, deals with the development of certification tests for the new base line of the technical specifications SRS 3.0.0. The project has been commissioned for 1.5 million Euros to the partnership comprising the CEDEX, DLR, Multitel, RINA and INECO-TIFSA, lead by the CEDEX's LIF. The duration of the project is estimated to be 30 months.

It is worth mentioning in the international scope, the work performed by the Laboratorio de Eurobaliza. This work has substantially exceeded the initial expectations. It has included the verification tests for new Eurobalise and BTM (Balise Trans-

Eurobalise: track instrumentation with reference loop.



Eurobalise: field instrumentation for onboard equipment.

mission Module) producers from Europe and Asia. Finally, in a process promoted by the ADIF for increasing the reliability of the line Madrid-Lerida, the Laboratorio de Eurobaliza has worked closely with ADIF on the development of field instrumentation for recording electromagnetic signals in the frequency range used for the transmission and activation of Eurobalises. This latter activity, by request of the Innovation and Maintenance departments of the ADIF, has also included the development of an ambitious Eurobalises monitoring programme based on the automatic analysis of the data stored in the Juridical Recording Units of the Commercial trains. The technical support provided to the ADIF is materialised in the production of track instrumentation and laboratory tests.

The Laboratorio de Eurobaliza of the LIF has maintained its accreditation as a European reference laboratory and has started the process to extend this accreditation to include BTM tests, an accreditation that is expected to be obtained in 2010. It is worth mentioning the relevance of this accreditation: the Laboratorio de Eurobaliza and the Italian RINA are the only two reference laboratories for Eurobalises tests throughout the world. The CEDEX expects to sign a cooperation agreement with the Italian laboratory to allow the exchange of experts, as well as the development of crossed comparison experiments, required for preserving the accreditation.

The CEDEX's new Director has strongly promoted R&D&i aspects, which has permitted the Laboratorio de Interoperabilidad Ferroviaria to take up again the Euroloop project investing on its own resources. The Laboratorio de Eurobaliza has thus been equipped with the necessary instrumentation for Eurolazo frequencies. This is a strategic component that can be of immediate application on the Spanish railway network, particularly on short distance trains. It is currently being developed by Spanish companies from the railway sector.

The work carried out by the LIF within Spain has focused on the provision of technical assistance to the Ministerio de Fomento (Ministry of Transport), to the Administrador de Infraestructuras Ferroviarias (ADIF, Administrator of Railway Infrastructures) and to the railway operator (RENFE), as well as to private companies working in the railway sector, such as CAF. It is worth mentioning a crucial aspect of the activity developed throughout 2009, that is the pioneering use of the Laboratorio de Referencia de Eurocabina by the Dirección General de Infraestructuras Ferroviarias (DGIF, General Directorate of Railway Infrastructure) to carry out complementary tests to put in service the project ERTMS Level 1 for the commuter network of Madrid. This laboratory check is performed by automatic transposition of the project design data (Telegrams and track description) and connection of real equipment (Onboard ETCS) to the reference tools. The first application has posed a challenge, as the track design engineering has been done by the temporary partnership between the companies Invensys and Thales, while the short distance trains are being equipped with Eurocabs developed by Alstom and Invensys. It is worth noticing the collaborative attitude of the companies involved in the project. This attitude has clearly favoured the tests being now performed in the laboratory. The first results show the agreement between the observations taken in-situ and from the laboratory.

Thanks to use of the Reference Laboratory and, in particular, to the use of the reference model of Eurocab , that is, the TSD developed for the European campaigns, it has been possible to detach in the laboratory the track validation tests from the tests

for validating the Onboard ERTMS system. This has been achieved through a process in three stages:

• Off-line verification of track engineering design. Verification of the compliance with the engineering guidelines defined by the ADIF.

• Validation of the interoperability of the ERTMS infrastructure design by performing complementary tests using the TSD and the reference tools fed with the data from the infrastructure design project.

• Validation in series of the on-board equipment by connecting them to the reference tools fed the infrastructure design data validated in the second stage of the process.

This strategy brings along good perspectives for the future. The ADIF has commissioned its application on the start-up of the line Madrid-Valencia/Albacete in the year 2010, while the European Commission has expressed a great interest on the use of independent reference laboratories from the year 2012 to guarantee the interoperability of European freight corridors the Commission is involved in.

This promising evolution will only be ascertained if the strategy extends to Level 2 of the application, which requires the connection of Radio Block Centres (RBC) to a traffic simulator fitted with the European architecture. This complex step requires adapting the communication protocols and functionalities of the RBCs connected to the simulated control centres and interlockings, as well as of other RBCs and on-board ERTMS equipment which are also simulated. This mix of real and simulated equipment will enable in the near future the validation of traffic control functions enclorsed in Level 2 of the ERTMS application. This is the main objective of the Laboratory for the year 2010, already started in 2009.

The LIF wants to face this necessary process of technological development without neglecting the current activities for starting-up different processes.

Thus, the LIF has taken active part in the campaigns for performing complementary tests for the initial starting-up of Level 2 of the ERTMS application on the line Madrid-Lerida. This line is equipped by Ansaldo with series S-102 and S-103 trains, fitted with Siemens equipments.

In order to cope with the growing demand for support on validation processes both on track and in laboratory, the CEDEX has closed a strategic alliance with INECO-TIFSA to coordinate the groups of professionals from both institutions on each of the two fields: laboratory and track. This alliance is complemented with the alliance established with the other European laboratories: DLR, Multitel and RINA. The demands of the European Commission will be covered in the near future under this alliance.

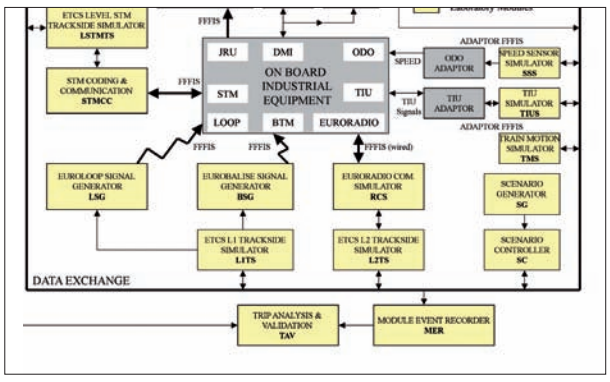
THE ROLE OF THE REFERENCE LABORATORY IN THE VALIDATION OF COMMERCIAL PROJECTS

The architecture of a reference laboratory, described in the Subset-094 of the interoperability directive is normally used for the certification of ETCS on-board equipment with no reference to a particular project. The equipment subject to study is connected to the testing equipment through two interfaces for brakes and speed sensors. The theoretic sequences of Subset-076 of the interoperability directive are then loaded on the Scenarios' Controller (SC) of the test bench. This device dispatches the messages through the Level 1 and Level 2 track simulators. The equipment being tested is connected to the testing equipment as a whole and is subject to no modifications. The recorded data is later analysed by experts using analysis tools specifically developed by the Laboratory staff.

For the implementation of a particular project, a number of complementary tests are carried out for verifying operational aspects and engineering guidelines. This process involves a large number of tests that are generally performed in-situ on the track requiring substantial human and material resources, which are often scarce and expensive. The Spanish experience has been a good example due to the need for starting-up lines and trains from different providers.

From the track to the laboratory.

In order to reduce the number of complementary tests performed on track, the CEDEX, with support from the Ministerio de Fomento (Ministry of Transport), the ADIF (Administrator of Railway Infrastructures) and RENFE (Spanish railway operator), has implemented a new validation strategy based on the application of reference tools from Subset-094, fed with sequences generated using the data provided by the manufacturers. The objective of this new strategy is not to get rid of tests on track, but to reduce the number to the strictly necessary, such as train-track integration, train dynamic, verification of certain engineering data, etc.



Reference architecture (Subset-094).

To test a commercial project in the laboratory, the data provided by the manufacturer are converted into the format of the laboratory Scenarios' Controller, automatically and without any manipulation, in order to guarantee their integrity. Thus, the data provided by the manufacturer is converted into the common European format of the Scenarios Controller, the core of the reference tools. For this purpose, the Laboratorio de Interoperabilidad Ferroviaria (LIF) has developed a new tool called Generador Automático de Escenarios (GAE, Automatic Scenarios' Generator). Thanks to this tool it is possible to perform complementary tests with reference tools from Subset-096 and test sequences with the format of Subset-076 sequences with the format of Subset-076.

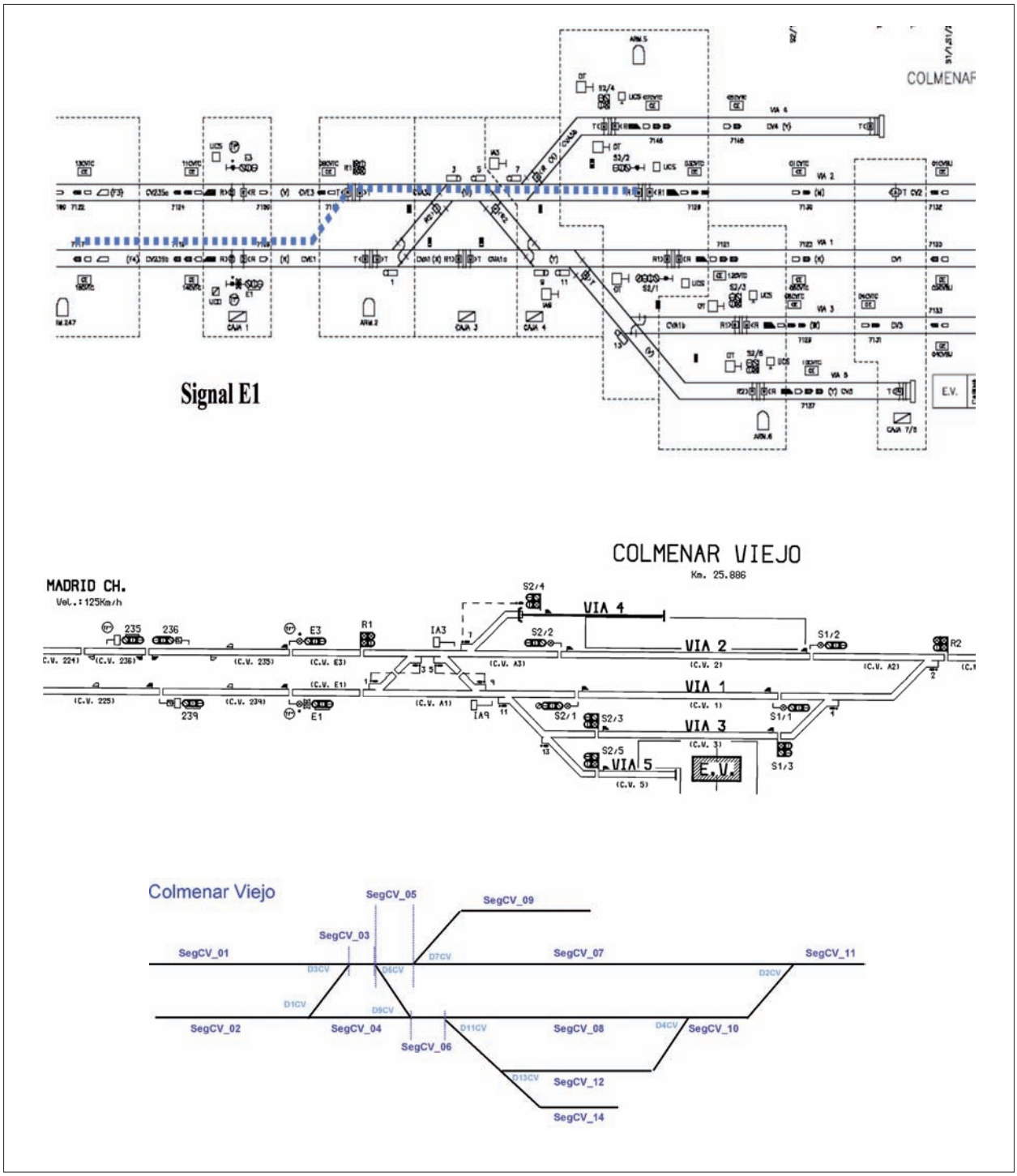
The GAE tool is currently being used for the starting-up of the Commuter Network of Madrid, fitted with ETCS track equipment by Dimetronic and Thales and run with trains equipped with ETCS by Alstom and Dimetronic. The Level 1 validation tests on the line Madrid-Valencia/Albacete have also begun. All companies involved have provided the CEDEX with the project design data, a fact that gives an idea of their deep support to the new strategy.

The example of the Commuter Network of Madrid

The section Tres Cantos-Colmenar of the C5 line of the Commuter Network of Madrid was selected as pilot section for the first phase of the validation.

The following figure shows, on its upper section, the diagram of the signalling equipment displayed at the entry to Colmenar Viejo station. This figure also shows an itinerary for entering the station in On Sight Mode (Occupied Track). On the lower section of the figure we find the signalling equipment used in the selection of itinerary. In the middle section, this figure shows the location of signalling equipment and on the lower section, the basic elements for the choice of route (equipped track sections).

The first step in the selection of a setting consists on identifying the basic elements, such as signals, track circuits, switches, etc., that take part in the choice of route in accordance to the setting. Starting from the identification of the basic element, the GAE tool links them together to generate the Movement Authority (MA) required for the implementation of the scenario.



Thus, for example, following the route of the example, the following elements are linked together:

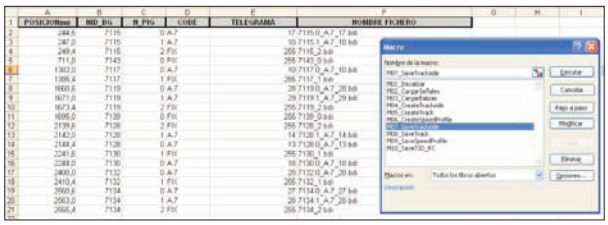
Starting at the circuit of track 239CV, corresponding to the segment connecting to signal E1CV, the location of which is permissive for the entrance to the track, the route selected connects with the station's exit signal, S1/2. The switches D1CV and D3C are in the deviation position (-) for changing tracks, and the switches D5CV and C7CVare in normal direct position (+). This selection of elements connects the entrance segment with the station's exit signal. The selection process using the GAE tool is shown in the following figure:

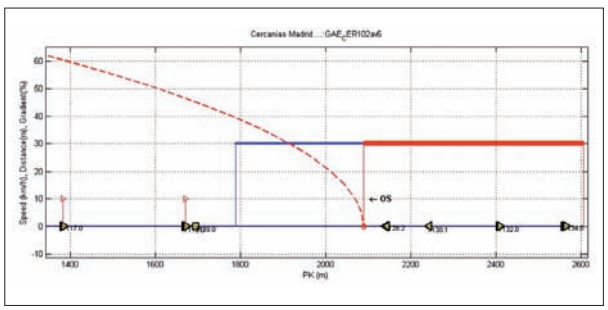
Pursuing with the definition of the operational setting, one of the possible alternatives for each element is selected. This is done by selecting one of the possible telegrams associ-

SEÑAL INICIAL	PK(m)	SENTIDO	ASPECTO	SEÑAL FINAL	Mov. ERTMS	Index 1	Index 2
239CV	24059	BUR	Proceed	Signal E1CV	159	607	636
E1CV	25483	BUR	OnSight	Signal S12CV	318	698	711
Aguja1	D1CV-		Aguja2	D3CV-			
Aguja1	D5CV+		Aguja2				
Aguja1	D7CV+		Aguja2				
S22CV	25927	MAD	Parada	Signal S22CV	134	618	681
S12CV	26372	BUR	Parada	Signal S22CV	122	489	502
Aguja1	D2CV+		Aguja2				

ated with the Signal aspect corresponding to the route selection. The telegrams are provided by the line supplier. This process enables at last the definition of the track characteristics in the format of the reference tools:

The graph of the setting with the representation of the movement authorization, speed profiles and acknowledgement window is shown in the following figure:





Validation strategy using laboratory tests

The use of reference tools defined for certification tests enables the introduction of an efficient testing strategy in three consecutive stages:

1. Off-line verification. The conversion of project telegrams into the format of the laboratory enables the verification of compliance with the engineering rules set by the infrastructure manager.

2. Line validation against a Reference Eurocab. For the initial step, the settings corresponding to complementary tests defined by the Ministerio de Fomento, ADIF and RENFE are performed in the laboratory using a functional Eurocabin model developed by ERSA and perfected by the network of reference laboratories for their European projects. Thanks to this, it is possible to verify that the infrastructure data is compliant with the European Interoperability Directive.

3. Validation of on-board equipment against the validated line. Lastly, a real ETCS on-board equipment is connected. This equipment is provided either by the railway operator or by the company responsible for equipping the trains. The scenarios corresponding to the complementary tests are run. The ETCS on-board equipments are thus validated against a validated line.

The route towards laboratory validation of Level 2 projects

The development of laboratory scenarios for validating Level 1 ERTMS projects is possible in principle because all possible telegrams exchanged between the track and the train are known a priori. The validation of Level 2 ERTMS projects is more complex since it requires the connection with a real Radio Block Centre (RBC). The interfaces with this device with interlockings and control centres are not normalized, for they don't affect interoperability.

The reference tools of the European Subset-094 have been extended in the LIF incorporating simulators of interlockings and control centres. The connection of a commercial RBC to the tools requires an active collaboration with the manufacturer to adapt the logic and physic communication protocols of the real RBC with the simulated interlockings and control centres.

It is possible to adapt communication and functional protocols between a commercial RBC and simulators incorporated to the reference tools. It has already been done internally in the companies that have developed this product. These companies have granted their support to the process for the validation of Spanish infrastructure projects.

Commuter Network of Madrid: Alstom Eurocab tests against Dimetronic's track engineering design.

This broadening of the reference tools will soon enable the contribution of the Laboratory to the validation of Level 2 ERTMS projects, through a 3-step strategy (Off-line verifications and uncoupling of the validations for track design projects and trains). The advantages already observed for the verification of Level 1 will be present here as well. Thanks to this, it will also be possible to test requisites that could not be verified thus far, such as the verification of traffic management capacity using one piece of real on-board equipment and a number of simulated ones, as well as the tests for train transfer between RBCs using a commercial RBC connected to the tools, and a further simulate one.

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UNISIG SUBSET–036 FFFIS for Eurobalise

UNISIG SUBSET–076–0 Test Plan

UNISIG SUBSET–085 Test Specification for Eurobalise FFFIS

CENTRO DE ESTUDIOS HISTÓRICOS DE OBRAS PÚBLICAS Y URBANISMO

REPORT 2009

Among the work developed by CEHOPU throughout 2009, the refurbishment of the Winthuysen Historic Garden is worthy of mention. This garden is included in the set of interventions being developed by the CEDEX in order to rationalize the use of existing outdoor spaces available on the Cerrillo de San Blas. Additionally, CEHOPU has continued working on the same line as in previous years with the development of a number of research projects, with the study and broadcasting of the history of technology, infrastructure, urbanism or outstanding figures of these fields. This work is publicised through exhibitions, publications, congresses, etc.

EXHIBITIONS

In 2009, CEHOPU has developed, in collaboration with various experts on the topic, the contents for the exhibition Reinforced Concrete in Spain 1893-1936. The opening of this exhibition is planned for January 2010 in the Sala Arquería in Nuevos Ministerios (Madrid).

The exhibition aims to present the arrival and initial development in Spain of constructions made of concrete, one of the most representative construction materials for the 20th Century that today forms part of our everyday landscape. Furthermore, the exhibition will help to broadcast the Spanish engineering and architecture from the first third of the 20th Century through introduction to the most representative works and figures of the construction field at the time. The exhibition focuses on the process by which the use of the new material entered Spain and became consolidated. This is narrated through the milestones and through the most relevant figures and constructions within the fields of Architecture and Engineering in the period from 1893 to 1936: from the reign of Alfonso XIII to the 2nd Republic.

CEHOPU is working alongside on the project for another exhibition entitled Sensible Equations: Art and Engineering of the 20th Century. The project is under development. During 2009, most of the research and selection work has been completed. Likewise, CEHOPU has contacted a number of museums, both in order to visit their collection and to study the possibility of organizing the exhibition in their premises. The objective of this exhibition is presenting engineering as a source of inspiration for the different artistic disciplines: photography, sculpture, painting, or even poetry, music or cinema. Therefore, the exhibition is focused on artists that show a particular interest on experimenting with the language of construction and engineering in the broadest sense, ranging from the materials used and the shapes and structures generated, to any meaning that may be related to the particular social and cultural environment.

The CEHOPU's program of itinerant exhibitions plays an important role in the broadcasting of the history of public works in our country. These itinerant exhibitions present many of the historic research projects and, to a certain extent, they are a further display window into the work of CEHOPU, of the CEDEX and of the Ministerio de Fomento (Ministry of Transport) itself. The itinerant spirit contributes, no doubt, to fulfil this ob-

Porto Pi petrol station. Casto Fernández-Shaw, 1927. Madrid

View of the itinerant exhibition Carlos Fernández Casado. Ingeniero in the Casa de las Ciencias, Logroño.

View of the itinerant exhibition España en el Mediterráneo. La construcción del espacio in the Arsenal of Palermo, Sicily.

jective, as the exhibitions travel to different cities throughout the country. This activity is developed in collaboration with other institutions and museums dependent on local authorities or autonomic communities. This collaboration translates into the lending of exhibition halls and into support with the organization of the exhibitions. Furthermore, CEHOPU has an important collection of models on the subject of history of public works that travel together with the itinerant exhibitions or that are, in turn, subject to being lent to other institutions for their exhibition.

The itinerant exhibition that has been presented in 2009 is Carlos Fernández Casado. Ingeniero. The exhibition aimed to explain and broadcast the professional career of one of the most relevant figures of the history of engineering in Spain. It was first opened on the 6th June 2007 in the hall of the Real Academia de Bellas Artes de San Fernando (Royal Academy of Arts of San Fernando, Madrid), and was open to the public until the 12th August. The exhibition takes the spectator through the life and work of this engineer (1905-1988), who was professor and designer of bridges and structures, as well as historian of public works and member of the Real Academia de Bellas Artes. Fernández Casado is one of the main figures of recent Spanish engineering of the 20th Century. The itinerant version was presented for the first time in Logroño, place of birth of the engineer, in the Casa de las Ciencias, by the river Ebro. The exhibition received a large number of visitors and was open from the 16th of June to the 13th of September.

One other exhibition produced by CEHOPU and exhibited in various locations throughout Spain is Spain in the Mediterranean Sea. Construction of space. The itinerant version was opened in Palermo, Sicily, with the occasion of the opening of the recently restored Arsenal Borbónico. The exhibition was opened on 17th December 2008 and closed on 25th February 2009. Back in Spain, it was exhibited in an international congress about ports and cities, organized by the Port Authorities of Santander. The exhibition was set up in the Palace of Embarcadero, from the 26th May until 28th June. The hall for temporary exhibitions of the National Museum of Subaquatic Archaeology of Cartagena (ARQUA), dependant of the Ministerio de Culture (Ministry of Culture), has been the latest destination of this exhibition. It was installed in the maritime environment of the new premises of the aforementioned museum. The opening took place on the 27th November, with the occasion of the celebration of the first anniversary of the opening of the new building. The planned closing date for the exhibition is the 28th February 2010.

Furthermore, Artifex. Roman Engineering in Hispania was opened in the MARQ of Alicante on the 27th December 2008, and remained open until the 15th February 2009. Subsequently, on the 5th of March it was installed in the Juan Carlos I hall of the city hall of San Fernando de Henares. This occasion was taken for organizing a programme of different activities and workshops for students of different age. The exhibition was closed on 19th April.

CONGRESSES

One again, CEHOPU has organised the symposium Aesthetics of the Environment: Public Works and Landscape, held on the 10th June in the premises of Palace of Zurbano. This third edition included the participation of forty experts from all disciplines involved, who presented different approaches to the subject.

RESEARCH

CEHOPU works towards the objective of contributing to the promotion and broadcasting of unpublished research projects by financing qualified researchers, working individually or as a team. In this line of work, the research projects funded through the third call of Research Bursaries were completed in 2009. Some of these projects were:

Timber roofs in historic constructions: Materials, transport, structures; The Azogue route between Almadén and El Viso (Cordoba); and Old hydraulic Infrastructure and water use in the river Nansa basin.

The subject areas CEHOPU has focused on, without omitting the subjects under the general framework of the history of public works and urbanism:

- The history of water infrastructures and their connection to land planning and organization.
- Landscape and evolution of transport networks and their connection to population centres in Spain.
- Study of the evolution of transport networks in Spain.
- Historic approach to singular transport infrastructures.
- The connection between transport infrastructures and networks with the evolution of Spanish cities.
- The evolution of the transport-land-landscape approach in Spain and Europe throughout the 19th and 20th centuries.

Alongside previous research tasks developed by the staff of the Centro, that have resulted in the exhibitions organized by CEHOPU, currently four doctoral thesis are being written by members of CEHOPU. The subjects of these theses are: Fortifications and New Layouts. Carlos de Grunenbergh, a European engineer servicing Carlos II in Italy; San Carlino alle Quattro Fontane: The extension of the 18th Century; Iron in construction. 19th Century; and Carlos Fernández Casado.

PUBLICATIONS

The editorial programme for 2009 was completed towards the end of the year. This programme comprises two new issues of the collection Cuadernos de Investigación CEHOPU (CEHOPU Research Booklets), the contents of which are based on the research projects financed by the Centro. Number 5, entitled El camino de Valencia en Alarcón y Contreras, 1845-1998. Análisis de viabilidad para su recuperación como carretera histórica (The road to Valencia in Alarcón and Contreras, 1845-1998. Viability study for its preservation as historic road), analyzes the heritage value of this road and defends its recognition as road heritage. In issue number 6, El depósito de Torroja en la Junta de Energía Nuclear. Estudio sobre su estado actual (Torroja's deposit in the Junta de Energía Nuclear. Study of the current condition), the author performs an in-depth study of the current state of this deposit, built in 1958. The particularity of this deposit is that the construction system used produced impermeable concrete walls without using steel or prestressing devices, and the aim of the study is to assess whether such a method would be valid today.

View of the itinerant exhibition Artifex. Ingeniería Romana en España in the MARQ of Alicante.

The collection Documentos para la historia de la Ingeniería (Documents for the history of engineering) has been extended with numbers 4, 5 and 6. Number 4, Los paisajes del agua en la cuenca del Ebro (Water landscape in the river Ebro basin) contains an inventory compiling all hydraulic infrastructures built throughout the centuries on the basin of the river Ebro. The documental sources preserved for these infrastructures are currently preserved in the Archivo General de la Administración (AGA) and in the Archivo General del Ministerio de Fomento. Number 5, edited with the intention of publicizing the collection of CEHOPU's 'Juan García Hortelano' library, includes the complete digitized magazine of Anales de la Construcción y de la Industria (1876-1890). Number 6 presents the results of three years of research on infraestructuras y aprovechamientos hidráulicos en Cantabria (Hydraulic infrastructure and water use in Cantabria), also developed thanks to the financial support to research activities. This issue has resulted in a documental and graphic catalogue that shall be a key reference document for any intervention done on the heritage preserved on the rivers of Cantabria.

With the occasion of the opening of the exhibition Reinforced Concrete in Spain, 1893-1936, two documents have been published. The first one, La imagen del hormigón armado (The image of reinforced concrete), is a recreation of the visual possibilities that can be achieved with reinforced

FROM LEFT TO RIGHT

Front cover of issue number 6 of the collection Cuadernos de Investigación CEHOPU.

Front cover of issue number 5 of the collection Documentos para la Historia de la Ingeniería.

Front cover of the book Los orígenes del Hormigón Armado en España.

concrete constructions. It features photographs of structures built in the early stages and still standing, taken by highly reputed photographers. The character of the second document is a different one: Los orígenes del hormigón armado en España (The origins of reinforced concrete in Spain) is based on the doctoral thesis written by the author. This thesis follows the history of reinforced concrete in Spain and describes the process followed by the first patents. The first section of the book analyzes the evolution of the construction material in the international sphere, to then move on to how it was introduced to Spain by the most representative figures to become a leading construction system at the time.

DOCUMENTATION

CEHOPU's Library has further increased/extended its catalogue, both through purchase and donations. The total number of books in the catalogue adds up to 8500. The number of periodicals is approximately 150. This year the library has started an exchange programme with various institutions, including the Casa de Velazquez and the Museo del Ferrocarril, both in Madrid, the Centro de Arte y Naturaleza in Huesca, or the Port Authorities of Gijón.

Carlos Fernández Casado website.

The Digital Library has also been expanded. Around 130 documents are available within the different collections:

- Selection of Spanish architecture and construction treatises, 16th-20th centuries
- Out-of-print publications by CEHOPU
- Selection of bridge treatises, 18th-20th centuries
- Agustín de Betancourt Digital Library
- Anales de la Construcción y de la Industria (1876-1890)
- Torroja Archive Digital Library
- Historic documents about Public Works
- Links

Furthermore, Carlos III University of Madrid has developed a Project entitled Automatización del entorno de gestión del fondo del ingeniero. Carlos Fernández Casado (Automation of the management of the engineer's collection. Carlos Fernández Casado). The aim of the project is to design and implement a system to manage the Carlos Fernández Casado Archive through the website of CEHOPU. This work fulfils a series of technical requisites related to archive regulations and provides a working environment that enables the introduction of descriptions and eases the management and its publication on-line. As far as the Torroja Archive is concerned, fifty of the main design projects by the engineer Eduardo Torroja have been digitized and will shortly be published. The documentation for the projects includes reports, drawings, sketches, calculations, specifications, etc., as well as photographs of the construction phase.

THE RESTORATION OF WINTHUYSEN HISTORIC GARDEN

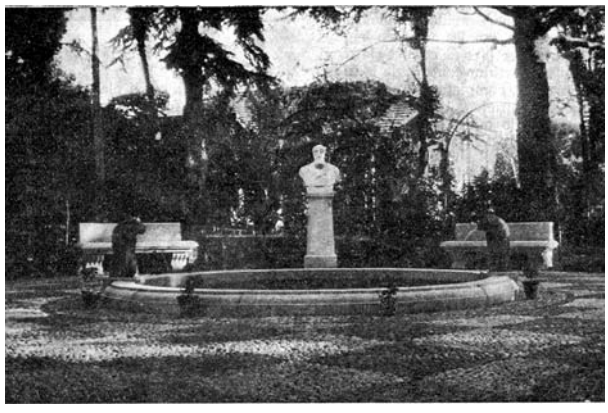
The restoration works of Winthuysen Historic Garden were completed in 2009. The garden was fully disfigured as a consequence of a large section being converted into a car park.

The project is developed on public land, set appropriated from the Astronomic Observatory in the 80's of the 19th century for the construction of the first School of Civil Engineering of Madrid, nowadays in use by the Ministerio de Cultura (Ministry of Culture). The new building was designed in 1881 and built between 1881 and 1882 by Mariano Carderera, Civil engineer and professor of the School. As antechamber and entrance to the building, an English garden was configured in 1887. This was a triangular heart-shaped garden with a road for carriages and a road exclusively for pedestrians. These roads covered the difference in level between the entrance on Alfonso XII street and the avenue of the Ángel Caído to the main door of the School, where they met at a small horizontal square. The rest of the garden was comprised of a meadow planted with trees. Of particular importance were the conifers (cedar, pine and yew trees), planted before the building was planned, and most of which still remain in their original location today. Throughout the pedestrian path, lines of horsechestnut and lime trees were planted, composing a pleasant and shady tree tunnel.

Years later, during the 1925-26 academic year, the garden was renovated. In this intervention, the layout was altered, and the slopes and pavement of the access paths were modified. Furthermore, a new avenue to access the Electromechanics Laboratory, to the south of the original building, was constructed. The works were completed with complementary gardening interventions performed in the 1926-27 academic year, motivated by the messy aspect of the vegetation by then. The aim was to respect, for convenience and economic reasons, the structure of the existing land and the trees, in particular noble and monumental species. This project was commissioned to Javier de Winthuysen (1874-1956), an expert in this field. He preserved and used the existing elements and structure, demonstrating his respect for the past evolution of the garden. The reform consisted on the opening of new paths and small squares to keep inside the existing plants, favouring the scattering of people in a very busy place at the time. The old trees thus remained within plant beds, giving the appearance that they had been planted following the design of the garden. This increased the value of the garden and provided new view points. Making use of an almost horizontal clearing in the land, a circus was generated (the Circus of Saavedra), the main entrance of which was through the central pedestrian avenue. A pond was built in the middle of the circus. Two lions made by the sculptor Barral were installed along the round edge of the pond. These lions ser-

Partial view of the garden before the intervention.

Partial view of the garden after the intervention.



Early 20th century view of the circus of Saavedra.

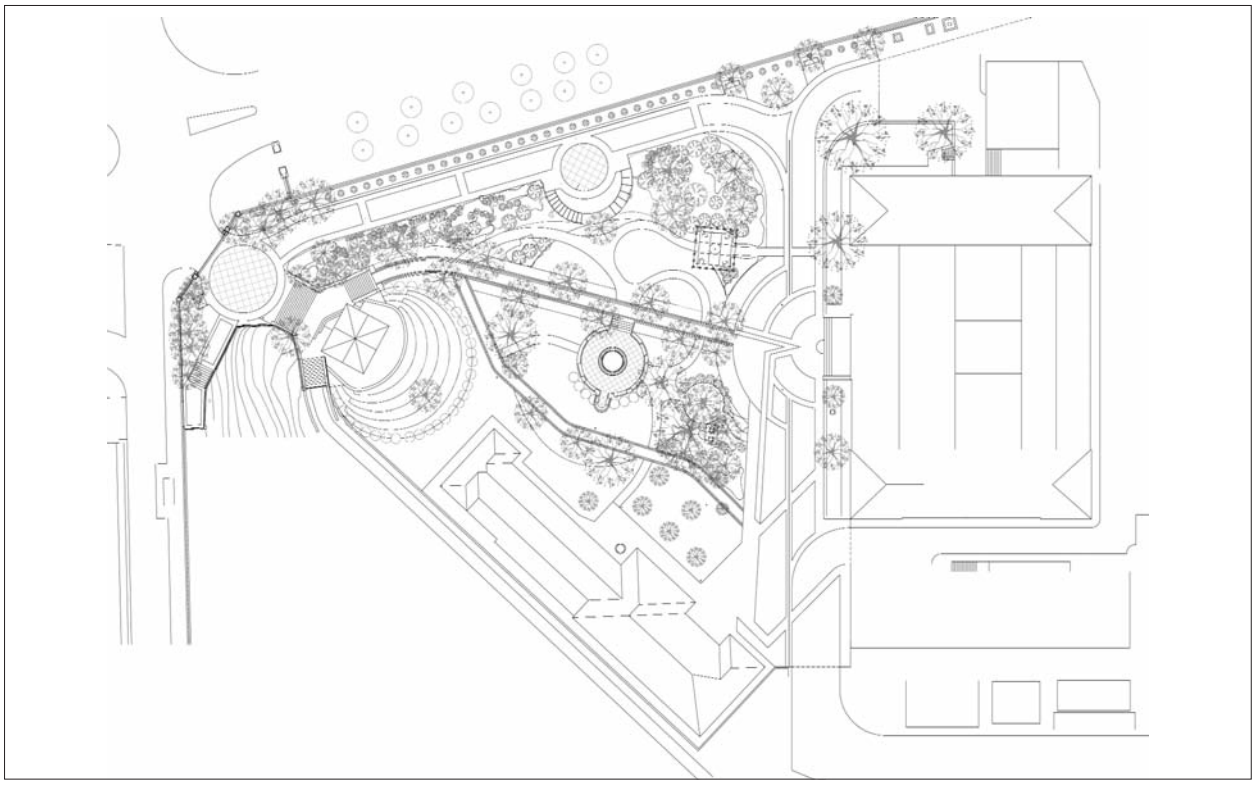
ved as spouts and each held a crest: one with the coat of arms of Spain and the other with the coat of arms of the Civil Engineers Body. Six banks were installed along the perimeter of the circus, framed by a series of cypresses, now restored and back in their original location.

On the other side of the main path, a square was built following the regional style of Andalusia, enclosed by low brick walls with four axial entries. Around the two spaces, the circus and the square, Winthuysen introduced some colour in order to create scenes depicting the change of season thanks to tapestry plants. The slope from the pedestrian path to the old carriages road was covered with appropriate shadow tapestry plants and, to break the monotony, two purely decorative stairs, curved and symmetrical, were built.

The recent restoration of the garden has aimed to bring back the identity of the place as a garden, based on the original design by Javier de Winthuysen and making used of a language of dialogue between the old and the new. In order to achieve this, one of the first interventions consisted of recovering the original extension of the garden, which had been substantially reduced by the gradual expansion of paved areas for their use as car park. The garden has thus been rescued and the original layout recovered. Furthermore, the original elements of the Saavedra circus have been put back in place.

The basic objectives of the intervention derive from the preliminary studies developed under a collaboration convention with the Departments of Architectural Design; Urbanism and Land Planning; and Graphic Design of the Universidad Politécnica of Madrid. The historic evolution of the garden and its current state before the intervention were studied in these departments, both from the point of view of the vegetation and from the point of view of circulations and uses.

Respecting the four initial objectives of Winthuysen has been crucial in the aim to restore the original design and extension of the historic garden: creating a green foyer with ornamental vegetation in front of the building of the School of Civil Engineering; preserving the existing trees; providing shade to the main path and creating green halls for pedestrians to rest within. To achieve this, the pedestrian access paths have been preserved, which still kept their original layout and paving of granite stones, and the layout designed by Winthuysen has been recovered by rebuilding the curved paths converging on the primitive access path. The missing lines of trees along this path have been recovered by planting staggered lime trees in order to optimize their growth and sun light.



General layout of the Winthuysen garden.

View of the garden from the pedestrian path accessing the Old School of Civil Engineering.

Present view of the circus of Saavedra.

View of the restored Winthuysen garden.

The three spaces –squares and circus– created by the author have been recomposed in their original position and intimate atmosphere. The Saavedra circus, called so because a bust of the engineer Saavedra was originally placed there, has been rebuilt with the existing original elements. These were preserved in a patio of the present School of Civil Engineering and were restored and cleaned before being returned to the garden. The old Andalusian ceramic square has been lost and in the present intervention it has been replaced by a singular element in the style of a garden folie. This element is a cubic volume, the outline of which coincides with the original plan of the square. An enveloping space is created and the missing elements designed by Winthuysen are recalled. The large ornamental piece on the edge of the northern embankment has also been reinterpreted and adapted to the new level of the ground. The double semi-circular stair has been recovered thanks to a weathering steel curved surface that contains the embankment, with weathering steel rises and soil steps planted with tapestry plants.

Regarding the plants in the garden, the high number of different species has been restored to fulfil the original idea of green envelope providing the garden with foliage, intimacy and shelter. The species have been selected according to their adaptability to the conditions of the environment (soil, climate, humidity, light exposure, etc.) and to their adaptability to the geometrical shapes they must adopt, the foliage, the texture, colour and aspect throughout the year, thus composing a garden with changing perceptibility. The tree collection is partly comprised by the preserved existing trees, and partly by some new trees delimiting paths and spaces or neutralizing the height of the nude trunks belonging to the original trees. Bushes are generally used along lines that, depending on the species, introduce different shapes, sizes, textures or colours, always within a chromatic or qualitative range that does not disrupt the sense of unity in the composition. The ground is almost completely covered by tapestry plants.

The old house of the guard and the old sentry box, both in an advanced state of decay, have been restored and transformed into and Information Centre for the Cerrillo de San Blas and a small warehouse respectively.

ANNEX

COURSES, CONFERENCES AND SEMINARS

CEDEX INTERNATIONAL MASTERS AND COURSES

Máster en Hidrología General y Aplicada. Madrid, 1 de febrero a 27 junio. CEDEX, AECID y otras instituciones.

Máster en Ingeniería de Puertos y Costas. Madrid, 1 de febrero a 27 junio. CEDEX, AECID yotras instituciones.

Máster en Mecánica de Suelos e Ingeniería de las Cimentaciones. Madrid, 1 de febrero a 27 junio. CEDEX, AECID y otras organizaciones.

CEDEX COURSES, CONFERENCES AND SEMINARS

3as Jornadas Hispano-Portuguesas sobre Geotecnia en las Infraestructuras Ferroviarias. Madrid, 25-26 junio 2009. CEDEX Cuéllar, V. y Lozano, A. *Comportamiento mecánico de zonas de transición españolas.* Conferencia especial.

Asamblea Anual de la Plataforma Tecnológica Ferroviaria Española

Asamblea de la Plataforma Tecnológica Española de la Construcción. Madrid, 9 diciembre. CEDEX en colaboración con la PTEC.

Curso de Aceros estructurales y del hormigón para Técnicos de Laboratorio. CEDEX en colaboración con INTEVIA.

Curso de Calidad de aguas. Montevideo (Uruguay), 20-24 julio 2009. CEDEX en colaboración con la DGA.

Curso de Control de calidad de materiales para firmes: ensayos de campo. CEDEX en colaboración con INTEVIA.

Curso de Hidrogeología I. Santa Cruz de la Sierra (Bolivia), 24-28 agost 2009. CEDEX en colaboración con la DGA.

Curso de Hidrogeología II. Ciudad de Panamá (Panamá), 26-31 octubre 2009. CEDEX en colaboración con la DGA.

Curso de Hormigón para Técnicos de Laboratorio. CEDEX en colaboración con INTEVIA.

Curso de Prevención, diagnosis y estudio de patologías del hormigón: Módulo I. CEDEX en colaboración con INTEVIA.

Curso selectivo de acceso a la Escala de Técnicos Facultativos Superiores de OO.AA. Madrid, 23 abril-7 mayo 2009. CEDEX en colaboración con el Ministerio de Fomento.

Curso selectivo de acceso al Cuerpo de Ingenieros de Caminos, Canales y Puertos del Estado. Madrid, 13 abril- 31 julio 2009. CEDEX en colaboración con el Ministerio de Fomento
Magdaleno, F. *Restauración fluvial y establecimiento de caudales ambientales*
Martínez Romero, R. *Nuevas tecnologías aplicadas a la gestión fluvial.*

Curso selectivo de acceso al Cuerpo de Ingenieros Técnicos de Obras Públicas. Madrid, 9 marzo- 25 junio 2009. CEDEX en colaboración con el Ministerio de Fomento
Magdaleno Mas, F. *Restauración fluvial y establecimiento de caudales ambientales*
Martínez Romero, R. *Nuevas tecnologías aplicadas a la gestión fluvia* **.**

Curso sobre Agua y medio ambiente, hidrología y modelación (I). Santa Cruz de la Sierra (Bolivia), 18-22 mayo 2009. CEDEX en colaboración con la DGA.

Curso sobre Agua y medio ambiente, hidrología, modelación (II). Cartagena de Indias (Colombia), 7-11 septuembre 2009. CEDEX en colaboración con la DGA.

Curso sobre Calidad de aguas II. Cartagena de Indias (Colombia), 3-6 noviembre 2009. CEDEX en colaboración con la DGA.

Curso sobre Clima y eventos extremos I. Antigua (Guatemala), 30 junio-3 julio 2009. CEDEX en colaboración con la DGA.

Curso sobre Clima y eventos extremos II. Santa Cruz de la Sierra (Bolivia), 9-13 noviembre 2009. CEDEX en colaboración con la DGA.

Curso sobre Diadem y Signal Express. Madrid, 27 abril-7 mayo. CEDEX.

Curso sobre Diseño de carreteras. Madrid, 1-6 junio 2009. CEDEX en colaboración con el Ministerio de Fomento.

Curso sobre Diseño de Ferrocarriles. Madrid, 16-20 noviembre. CEDEX en colaboración con el Ministerio de Fomento.

Curso sobre el Proyecto Directorio Activo. Madrid, 1 junio. CEDEX.

Curso sobre Gobernabilidad del agua: Aspectos económicos, agua potable y saneamiento, aguas transfronterizas, recursos hídricos y cambio climático. Montevideo (Uruguay), 7-11 septiembre 2009. CEDEX en colaboración con la DGA.

Curso sobre Incidencia para la gobernabilidad. La gobernabilidad del agua en Iberoamérica. Antigua (Guatemala), 16-20 febrero 2009. CEDEX en colaboración con la DGA.

Curso sobre Los sistemas de información geográfica en el manejo de cuencas. Madrid, 14-18 diciembre 2009. CEDEX en colaboración con la DGA.

Curso sobre Planificación, manejo y gestión de cuencas (GIRH) (I). Cartagena de Indias (Colombia), 2-6 marzo 2009. CEDEX en colaboración con la DGA.

Curso sobre Planificación, manejo y gestión de cuencas (GIRH) (II). Santa Cruz de la Sierra (Bolivia), 20-24 julio 2009. CEDEX en colaboración con la DGA.

Curso sobre software MIKE21, MIKE3, ECOLAB.

Curso sobre Tecnología ITIL (I). Madrid, 9-12 febrero. CEDEX.

Curso sobre Tecnología ITIL (II). Madrid, 23-25 febrero. CEDEX.

Curso sobre Tecnologías no convencionales para depuración de aguas residuales (I). Sta. Cruz de la Sierra (Bolivia), 16-20 febrero 2009. CEDEX en colaboración con la DGA.

Curso sobre Tecnologías no convencionales para depuración de aguas residuales (II). Antigua (Guatemala), 10-14 agosto 2009. CEDEX en colaboración con la DGA.

II Jornadas de Presentación de Proyectos I+D+i ligados al PEIT. Madrid, 24-26 febrero 2009. CEDEX Beloqui Urmeneta, L. (Organización).

III Curso sobre Evaluación Ambiental Estratégica: un instrumento para el desarrollo sostenible. Madrid, 23-27 marzo. CEDEX.

Jornada de Cálculo de túneles SEMR. Madrid, 22 abril. CEDEX.

Jornada de presentación del Manual de Diseño, Construcción, Explotación y Mantenimiento de Balsas. Madrid, 18 mayo 2009. CEDEX con la

colaboración de: Ministerio de Fomento, MARM, ATEBA y CNEGP
Estaire, J. *Estudios del terreno y los materiales*
Lechuga, C.y Granell, C. *Estudios de carácter hidráulico*
Leiro, A. *Sistemas de Impermeabilización. Otros Geosintéticos*
Martínez, J. M. *Criterios generales de diseño.*
Martínez, J. M. *Recomendaciones constructivas. Movimiento de tierras.*
Martínez, J. M. *Tipología del dique de cierre*
Perucho, Á. *Análisis de estabilidad.*

Jornada sobre Ensayos de penetración estática en el proyecto geotécnico. Madrid, 2 junio. CEDEX.

Jornada sobre Explotación de carreteras y medio ambiente. Madrid, 22 octubre. CEDEX en colaboración con ATC. Ruiz Arriaga, S.

Jornada sobre Lechadas Bituminosas y Microaglomerados en Frío. Madrid, 29 octubre 2009. CEDEX en colaboración con ATC-ASEFMA.

Jornada sobre Rehabilitación en la edificación. Madrid, 21 mayo 2009. CEDEX en colaboración con ACIES.

Jornada sobre Riego. Madrid, 15-26 junio 2009. CEDEX.

Jornada Técnica Prefisurización de capas tratadas con cemento. Madrid, 29 septiembre 2009. CEDEX En colaboración con ATC.

Jornada Técnica sobre los Aspectos medioambientales y ecológicos en la gestión fluvial. Perspectiva internacional. Madrid, 23 marzo 2009. CEDEX.

Jornada técnica sobre Mapas estratégicos de ruido de aglomeraciones: Experiencias de la 1ª fase y perspectivas. Madrid, 10 diciembre 2009. CEDEX en colaboración con el Ministerio de Fomento y el MARM.

Jornadas de Ingeniería del Agua 2009. Madrid, 27 y 28 octubre. CEDEX, FFIA y Capítulo Español de la IAHR
Alonso, M.E.; Ferrer, Y. y García, A. *La calidad de las aguas urbanas en los programas de medidas*
Balairón, L.; Bladé, E.; Corestein, G.; Cea, L.; Lara, A.; Dolz, J. y Puertas, J. *Desarrollo de un modelo de simulación de flujo en ríos.*
Barranco L.M.; Álvarez, J. y Potenciano, Á. *Impacto del Cambio Climático en los Recursos Hídricos en España*
Catalinas, M.; Alonso, M.E. y García, A. *Caracterización de las medidas de restauración de ríos en la planificación hidrológica*
Iglesias, R. y Ortega, E. *Tecnologías de regeneración a aplicar en función de los usos establecidos en el Real Decreto 1620/2007 sobre reutilización de aguas depuradas y sus costes asociados*
Jiménez, A. y Mediero, L. *Caracterización del comportamiento estadístico de los caudales máximos anuales y estacionales de los ríos de la España peninsular. Análisis y propuesta de procedimientos para su determinación*
López, D.; Marivela, R. y Aranda, F. *Calibración del modelo SPH empleando datos de presión de prototipo del cuenco de amortiguamiento de la presa de Villar del Rey, España*
Marcuello, C. e Incio, L. *Estudios Hidrológicos e Hidráulicos en el marco del Sistema Nacional de Cartografía de Zonas Inundables*
Martínez García, R.C. y Cordero, M.D. *Modelo físico del aliviadero de la presa de Calanda*
Ortega, E.; Ferrer, Y.; Salas, J.J.; Aragón, C. y Real, A. *La depuración de las aguas residuales para pequeñas poblaciones*
Sordo, A.; Jiménez, A.; Garrote, L. y Martín, f. *Evaluación sobre la conveniencia de considerar el efecto laminador de los embalses para el diseño de aliviaderos, utilizando información generalmente disponible*
Toledo, M.A; Lechuga, C.; Campos, H.; Morán, R.; Berga, M.I. y Viña, P. *Caracterización de la rotura de presas de escollera por sobrevertido mediante la realización de ensayos en modelo físico*
Villaverde Valero, J.J. y Álvarez Rodríguez, J. *Sistema de Indicadores de Estado Hidrológico en España.*

Jornadas sobre Catálogo actualizado de residuos utilizables en la construcción. Madrid, 27 noviembre 2009. CEDEX en colaboración con el MARM.

Jornadas sobre Dinámica y Vibración en Ingeniería Civil. Madrid, junio 2009. CEDEX en colaboración con Aries
Navarro Colom, F. *Ensayos en el simulador sísmico*
Sáinz de Cueto Torres, F.J. *Estudio de Fatiga Experimental el Materiales*
Sáinz de Cueto, F.J. *Fatiga de Materiales en Elementos Estructurales.*

Jornadas sobre Modelos Matemáticos. Madrid, 3-5 junio 2009. CEDEX.

Link Workshop. Madrid, 19 noviembre. CEDEX.

Primeras Jornadas Técnicas sobre Dinámica y Vibración en Ingeniería Civil. Madrid, 23-24 junio 2009. CEDEX en colaboración con Aries Ingeniería
Cuéllar, V. *Medidas de rigidez de vía en zonas de transición de líneas férreas españolas*
Díaz Simal, P. *Auscultación de puentes: Caso Tren de Alta Velocidad.*

Reunión de la Organización Inter-Nodal. Madrid, 22 octubre. CEDEX.

Reunión Investigación de Carreteras en España I. Madrid, 27 mayo. CEDEX.

Reunión Investigación de Carreteras en España II. Madrid, 23 junio. CEDEX.

Reunión Proyecto Europeo Link Forum. Madrid, 2-3 marzo. CEDEX.

Reunión Proyecto Innotrak. Madrid, 4 febrero. CEDEX.

Reunión semestral YELGIP. Madrid, 1 abril. CEDEX.

Seminario CEDEX-BAM. Madrid, 7 julio. CEDEX.

Seminario de la Sociedad Española para la Comunicación Fija del Estrecho de Gibraltar. Madrid, 7-8 enero. CEDEX.

Seminario de Planificación del Transporte en España. Madrid, 24 marzo 2009. CEDEX.

Seminario sobre Comunicaciones Ferroviarias e Instalaciones de Seguridad. CEDEX en coordinación con el Instituto de Investigación Ferroviario (IIR)
Tamarit, J.

Seminario sobre Inspección, auscultación y mantenimiento de puentes. Montevideo (Uruguay). CEDEX en colaboración con AECID
Bermúdez, M.A. *Durabilidad, Vida útil, Patologías.*

Sesión Plenaria ERTRAC. Madrid, 9 junio 2009. CEDEX.
.

Sesión técnica La actualidad del postesado en la construcción. Madrid, 19 noviembre 2009. CEDEX en colaboración con ACIES.

XVIII Simposio internacional sobre Política y economía del transporte. Madrid, 16-27 noviembre 2009. CEDEX en colaboración con OCDE/MFOM.

XXVII Curso sobre Tratamiento de Aguas Residuales y Explotación de Estaciones Depuradoras. Madrid 16-27 noviembre 2009. CEDEX.

PARTICIPATION IN EXTERNAL COURSES

3rd IAHR Directors Workshop on Managing Change. Balairón, L. *New focus for research in hydro-environmental processes in Spain.*

5º Máster en Ingeniería Geológica
Estaire, J. *Cimentaciones superficiales especiales*
Perucho, Á. *Cimentaciones superficiales en suelos.*

ALERT Olek Zienkiewicz Course on Numerical Modelling in Geomechanics
Pastor, M. Tamagnini, C. Mira, P.: *Coordinadores*
Pastor, M. *Tres clases de teoría y tutela 12 horas de prácticas*
Mira, P. *Tres clases de teoría y tutela 12 horas de prácticas.*

Análisis de Imagen, Procesado y Técnicas
Prendes Rubiera, N. *Técnicas de Tratamiento de la Información, Problemas de escala y resolución.*

***Brainstorming* para el despliegue armonizado de los Corredores Ferroviarios Europeos**.
Tamarit, J. (Participante).

Contaminación litoral. Proyecto y construcción de emisarios submarinos.
Ruiz Mateo, A. *Contaminación litoral*
Ruiz Mateo, A. *Proyecto de emisarios submarinos.*

Curso de Conservación y Explotación de Carreteras
Astudillo, R. *Auscultación de estructuras. Tipología de obras de fábrica.*
Díaz Simal, P. *Patología de las obras de fábrica.*
Prendes Rubiera, N. *Aspectos Geológicos y Geotécnicos en obras de carácter lineal.*

Curso de Dotaciones Viales
Castillo, F. *Señalización vertical.*

Curso de verano La gestión del agua en las ciudades
Lechuga, C. *Guías Técnicas para el diseño de infraestructuras hidráulicas.*

Curso Fototrampeo y seguimiento de rastros en el medio natural
Morcillo, F. *Conservación de la ictiofauna de la Comunidad de Madrid. Participación y vigilancia de la guardería*
Morcillo, F. *Técnicas de muestro de peces de agua dulce.*

Curso General de Transportes Terrestres
Tamarit, J.

Curso Iberoamericano de Ingeniería Portuaria
Ruiz Mateo, A. *La Gestión de los productos de dragado.*

Curso Práctico sobre Estudios Geotécnicos para Edificación
Estaire, J. *Ensayos geotécnicos de laboratorio para rocas. Interpretación de resultados* Estaire, J. *Cálculo de cimentaciones superficiales en roca. Casos prácticos.*

Curso sobre Aplicaciones avanzadas y nuevas técnicas en proyecto y ejecución de obras con hormigones especiales.
Alaejos, P. *Ejecución del Puente de Hormigón Reciclado entre Paterna y Manises.*

Curso sobre Caracterización Porosa de Materiales Geológicos
Santiago, C. de.

Curso sobre Energía y Medio Ambiente. Perspectivas Científico-Técnicas y Sociales
Soriano, J. *Reutilización de materales para la Obra Pública.*

Curso sobre Patología Geotécnica
Estaire, J. *Patologías de obras de carretera: Metodología de estudio. Patología de rellenos*
Estaire, J. *Auscultación de presas*
Estaire, J. *Balsas de residuos: Caso de la Balsa de Barlovento*
Estaire, J. *Estabilización de rellenos y laderas mediante pasadores estructurales*
Estaire, J. *Patología obras de carretera: Caso de la CN-323*
González-Gallego, J. *Auscultación geotécnica: equipos de auscultación*
González-Gallego, J. *Casos prácticos I: Recalce de un edificio con inyecciones (Palacio de la Moncloa)*
González-Gallego, J. *Casos prácticos II. Obras de carreteras. (La Panadella)*
González-Gallego, J. *Casos Prácticos III. Presas, laderas y terraplenes (Deslizamiento de Formigal)*
González-Gallego, J. *Patología de Laderas*
González-Gallego, J. *Protección frente a desprendimientos mediante barreras dinámicas*
Pardo, F. *Introducción a la patología geotécnica*
Pardo, F. *Patología de presas de materiales sueltos*
Pardo, F. *Patología de vertederos de residuos sólidos*
Perucho, Á. *Auscultación de presas. Caso práctico*
Perucho, Á. *Balsas de residuos: Caso práctico*
Perucho, Á. *Cimentaciones en terrenos volcánicos*
Perucho, Á. *Patología de cimentaciones: Teoría y casos prácticos*
Perucho, Á. *Patología obras de carretera: casos prácticos*
Perucho, Á. *Resolución y discusión de los casos prácticos planteados.*

Curso sobre Sostenibilidad en ingeniería civil y reciclaje de residuos
Alaejos, P. (Directora)
Alaejos, P. U*tilización de residuos en construcción*
Sánchez de Juan, M. *Experiencia de la ejecución del tablero de hormigón estructural HA-35 con áridos reciclados del puente atirantado Manises-Paterna (Valencia).*

Cursos sobre Sistemas de Información Geográfica en el Manejo de Cuencas
Potenciano, Á. *Cartografía: Conceptos básicos, escala, proyecciones*
Potenciano, Á. *Ejercicio práctico V: Obtención de cuencas vertientes, red de drenaje y acumulación de las variables relacionadas con la contaminación agraria*
Potenciano, Á. *Manejo de Sistemas de Información Geográfica (II).*

II Jornadas sobre acústica ambiental y edificación acústicamente sostenible
Segués, F. *Experiencias de la aplicación de la Directiva 2002/49/CE*
Segués, F. *Mapas de ruido*
Segués, F. *Mapas estratégicos de ruido y planes de acción.*

International Centre for Mechanical Sciences (CISM). Udine (Italia), 8-12 junio. Pastor, M. *Mechanical behaviour of soils under environmentally induced cyclic loads.*

IX Máster en Gestión y Administración Ambiental
Segués, F. *Sistemas y técnicas de la evaluación del ruido ambiental.*

LARAM (Landslide Analysis and Risk Management) School of Risk Assessment. Ravello (Italia). Università degli Studii di Salerno
Pastor, M..

Máster de Climatologia Aplicada
Álvarez, J. *Sequías y recursos hídricos.*

Máster de Túneles (AETOS)
Estaire, J. *Teoría de la plasticidad. Parámetros característicos*
Cano, H. *El ensayo presiométrico autoperforante*
Estaire, J. *Ensayos de laboratorio. Rocas y suelos*
Perucho, Á. *Definición de tensiones. Tensor de tensiones*
Perucho, Á. *Deformaciones de fluencia. Viscosidad. Relajación de tensiones*
Perucho, Á. *Estabilidad de taludes en suelos. Refuerzo de taludes*
Perucho, Á. *Tensiones principales. Invariantes.*

Máster de Túneles (EITOP)
Perucho, Á. *Ensayos en roca*
Perucho, Á. *Propiedades de la roca matriz.*

Máster en Gestión fluvial sostenible y gestión integrada de aguas
Balairón, L. *Seguridad en infraestructuras hidráulicas*
Lechuga, C. *Guías y recomendaciones técnicas para las infraestructuras hidráulicas.*

Máster en Hidrología superficial y subterránea.
Álvarez, J. *Análisis de series históricas. Métodos para completar series históricas. Series sintéticas: utilidad y obtención*
Álvarez, J. *Las componentes del ciclo hidrológico. Obtención y validación de datos meteorológicos e hidrológicos. Balances hídricos en cuencas .*

Máster en Ingeniería Ambiental
García, A. *Los programas de medida*
Segués, F. *Índices de medida del ruido ambiental y aspectos normativos*
Segués, F. *Ruido de los ferrocarriles: Medidas preventivas y correctoras del ruido originado por el tráfico*
Segués, F. *Ruido de tráfico en carreteras.*

Máster en Ingeniería Ambiental
Antequera Ramos, M. *Contaminación Marina. Principales substancias contaminantes*
Ruiz Mateo, A. *Vertido al mar a través de emisarios submarinos*
Segués, F. *Caso práctico.*

Máster en Ingeniería y Gestión del Agua
Magdaleno Mas, F. *Cálculo y establecimiento de regímenes de caudales ambientales & Evaluación de la alteración hidrológica en ecosistemas fluviales.*

Máster en Restauración de Ecosistemas
Magdaleno, F. *Técnicas de restauraciónfluvial y valoración de daños en ecosistemas acuáticos.*

Máster Profesional en Ingeniería y Gestión Medioambiental
Segués, F. *Mapas de ruido*
Segués, F. *Cálculo de pantallas acústicas en carreteras.*
Segués, F. *Medidas correctoras*
Segués, F. *Métodos de medida y previsión*
Segués, F. P*antallas acústicas*
Segués, F. *Ruido de los ferrocarriles*
Segués, F. *Ruido del tráfico.*

Máster Universitario de Gestión de Zonas Costeras
Santás, J.C. *Corrientes, mareas, instrumentación y aplicación a casos práctico.*

Máster Universitario en Ingeniería del Agua y del Terreno
Álvarez, J. *Recursos hídricos*
Dimas, M. *Hidrometría e información hidrológica*
García, C. e Incio, L. *Hidrología*
Jiménez, A. *Métodos de cálculo de crecidas.*

Máster Universitario en Sistemas Ferroviarios
Tamarit, J.

Meeting EIONET National Reference Centres (NRC) for Noise
Muñoz, F.I.

Meeting EPOMM (European Platform on Mobility Management)

Programa de Postgrado en Tecnología, Administración y Gestión del Agua (TAyGA).
Álvarez, J. *Recursos hídricos*
Dimas, M. *Hidrometría e información hidrológica*
García, C. e Incio, L. *Modelación hidrológica con HEC-HMS*
Jiménez, A. *Métodos de cálculo de crecidas.*

Recents developments in nearshore coastal water quality research: Prediction, hydro-biological interactions and management
Lloret Capote, A., Ruiz Mateo, A., Marta Martínez-Gil, M. y Buceta Miller, J.L. *Coastal Water Quality Management: Spanish experience*
Part 2: New Classification Scheme for Water Status
Ruiz Mateo, A.; Antequera Ramos, M.; y Lloret Capote, A. *Coastal Water Quality Management in Spain. Part 1: Brine Discharges from Desalination Plants.*

Restauración y Rehabilitación Arquitectónica
Prendes Rubiera, N. *Aplicación del tratamiento digital de imágenes en la arquitectura.*

Universidad de Alcalá. Departamento de Ecología
García Sánchez-Colomer, M.R. *Profesor asociado.*

Universidad Rey Juan Carlos
Magdaleno, F. *La gestión de los proyectos de restauración fluvial en el Parque Regional del Sureste.*

VI Curso de Obras Hidráulicas en el Medio Forestal
Magdaleno, F. *Aplicación de técnicas de bioingeniería*
Martínez, R. *Introducción a la hidráulica de HEC-RAS.*

VII Curso de Aplicaciones Informáticas en Hidrología
Magdaleno, F. *Aplicaciones LiDAR en hidrología - IAHRIS, un modelo para la evaluación de la alteración hidrológica*
Martínez, R. *Cálculo de sedimentos con modelación RAS.*

VII Curso Superior en Políticas e Instrumentos de Gestión Ambiental
Segués, F. *El origen y efectos de la contaminación acústica*
Segués, F. *Soluciones al problema del ruido en el transporte y en la industria.*

XXI Curso Internacional de Técnicas de Riego y Gestión de Regadíos
Álvarez, J. *Influencia del cambio climático en los recursos hídricos*
García, J.R. *Influencia del cambio climático en la demanda de agua de riego.*

XXII Curso General de Transportes Terrestres
Segués, F. *Contaminación acústica en carreteras*

CONTINUOUS PROFESSIONAL DEVELOPMENT

Prevención de riesgos laborales.
2 cursos, 10 horas lectivas, 14 asistencias.

Habilidades personales.
5 cursos, 82 horas lectivas, 45 asistencias.

Desempeño del puesto de trabajo (bibliotecas, estadística, WoK).
7 cursos, 145 horas lectivas, 57 asistencias.

Idiomas.
17 cursos, 930,5 horas lectivas, 111 asistencias.

Tecnologías de la información y comunicaciones.
21 cursos, 630 horas lectivas, 207 asistencias.

Varios.
1 cursos, 4 horas lectivas, 23 asistencias.

PAPERS IN CONGRESSES, CONFERENCES AND SEMINARS

Agrela F., Geraldes V.L., Jiménez J.R., Ayuso J.M. *Mixed recycled aggregates characterization for application in manufacture of non structural concrete: correlations between physical and chemical properties.*
2nd International RILEM Conference: Progress of Recycling in the Build Environment.

Alaejos, P. **Jornada de presentación del Catálogo actualizado de residuos utilizables en construcción.** (Directora).

Alaejos, P. *La sostenibilidad en la construcción de puentes.* **Jornada sobre Financiación, construcción y rehabilitación de puentes y viaductos.**

Alaejos, P. *Recomendaciones para mejorar la calidad de los cajones de muelles portuarios: fase de proyecto y ejecución.* **Jornada sobre Aplicación de la nueva EHE-08 en obras marítimas.**

Alaejos, P. *Tarea 2.1. "Reciclado de RCD´s como áridos de hormigones estructurales".* **Jornada de presentación de las Tareas 2.1 y 2.2 del Proyecto CLEAM.**

Alaejos, P. y Bermúdez, M. A. *Influencia del curado con agua de mar sobre las propiedades del hormigón armado.* **Congreso Internacional de Patología, Control de Calidad y Rehabilitación de Estructuras y Construcción (CONPAT 2009).**

Alaejos, P. y Sánchez de Juan, M. *Novedades del Catálogo de residuos utilizables en construcción.* **Jornada de presentación del Catálogo actualizado de residuos utilizables en construcción.**

Álvarez, A.; Antequera Ramos, M.; Ruiz Mateo, A. *Estudio mediante modelo físico del comportamiento de la salmuera vertida en el interior de una dársena.* **X Jornadas Españolas de Costas y Puertos 2009.**

Antequera Ramos, M.; Lloret Capote, A. y Velasco Munguira, A. *Los bioensayos en la caracterización del material dragado.* **I Jornadas Ambientales.**

Antequera Ramos, M.; Obispo Esteban, R.; del Valls, A. y Rodríguez, A. *Aplicación práctica de los bioensayos al material de dragado.* **I Jornadas Ambientales.**

Antequera Ramos, M.; Obispo Esteban, R.; Del Valls, Á. y Rodríguez, A. *Determinación de umbrales de toxicidad y elaboración de protocolos analíticos en bioensayos para la caracterización ambiental de sedimentos marinos.* **X Jornadas Españolas de Costas y Puertos 2009.**

Aramburu, E. *Adaptación de la presa de Amadorio, Alicante, al Reglamento técnico de seguridad de presas y embalses de 1996.* **Seminario de la PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos).**

Aramburu, E. y Balairón, L. *Escalas de peces.* **Jornada Técnica sobre lechadas bituminosas y microaglomerados en frío**.

Asanza Izquierdo, E. y Martínez Santamaría, J.M. *Medida de la fricción entre un suelo cohesivo y geotextiles en un amplio rango de succiones.* **3º Seminário Português de Geosintéticos.**

Astudillo, R. *Coordinador.* **Jornada sobre Gestión, Seguimiento y Reparación de Puentes.**

Balairón, L. *Costes energéticos, financieros y ambientales comparados entre las TCZ y las TSZ.* **XI Jornada Internacional de Tecnologías sin Zanja.**

Balairón, L. *Las Guías Técnicas del CEDEX en materia de conducciones.* **4ª Jornada Técnica sobre las tuberías en los sistemas de abastecimiento y saneamiento.**

Balairón, L. *Sistemas de tuberías de PE.* **Jornada Técnica sobe tuberías de polietileno. Soldadura y aplicaciones.**

Balairón, L.; Lara, A.; Aramburu, E; Berges, J.A; García, J.L; Morcillo, F. y Castillo, M. *Study of effectiveness of fishways: Fish experiments in a vertical slot model scale 1:1.* **7th International Symposium on Ecohydraulics.**

Balairón, L; Bladé i Castellet, E; Corestein, G; Cea, L; Lara, A; Dolz, J y Puertas, J. *Desarrollo de un modelo de simulación de flujo en ríos.* **4º Simposio Regional sobre Ríos.**

Barranco, L.M. y Álvarez, J. *Cálculo del tiempo de concentración en hidrología con GRASS.* **III Jornadas de SIG Libre.**

Barrio, I del y Lloret, A. *A GIS developed for Spanish coastal and marine waters.* **Workshop on maritime and coastal information systems.**

Bermúdez, M. A. *Recomendaciones específicas para garantizar la durabilidad del hormigón de estructuras marítimas situadas en zona sumergida o de carrera de mareas.* **Jornada sobre Aplicación de la nueva EHE-08 en obras marítimas.**

Bermúdez, M. A. y Alaejos, P. *Evaluación de la durabilidad del hormigón armado en ambiente marino mediante diferentes métodos de ensayo.* **Congreso Internacional de Patología, Control de Calidad y Rehabilitación de Estructuras y Construcción (CONPAT 2009).**

Bladé, E.; Cea, L.; Corestein, G.; Aramburu, E.; Lara, A.; Puertas, J.; Gómez, M.; Dolz, J. y Balairón, L. *Desarrollo de un modelo de simulación de flujo en ríos.* **Seminario de la PTLHE. Líneas prioritarias A (Criterios hidromorfológicos para la recuperación de espacios fluviales degradados) y B (Hidrodinámica de embalses. Gestión sostenible).**

Blanc, T. y Pastor, M. *Numerical simulation of debris flows with the 2D - SPH depth integrated model.* **European Geosciences Union General Assembly 2009.**

Blanco, M. *Experiencia española en el empleo de geomembranas en la impermeabilización de balsas* **3º Seminário Português de Geosintéticos.**

Campos, P.; Gadea, J.; Soriano, J.; Martín, A.; Calderón, V. y Adán, I. *Reactividad álcali-sílice y álcali-silicato en pizarras.* **VII Congreso Ibérico de Geoquímica.**

Cano, H. *Aplicación del ensayo de piezocono a la valoración de parámetros de suelos cohesivos.* **Jornada CEDEX-UPC sobre Ensayo de penetración estática en el proyecto geotécnico.**

Cano, H. *Obtención de parámetros geotécnicos mediante el ensayo presiométrico.* **Jornada CEDEX-UPC sobre El ensayo presiométrico en el proyecto geotécnico.**

Cano, H. y Salinas, J.L. *Consideración del riesgo de inestabilidad de vertidos de mina mediante mapas de A_PENDIENTEs: las escombreras de estériles de Tremor de Arriba (León) como ejemplo de aplicación.* **VII Simposio Nacional sobre Taludes y Laderas Inestables.**

Carpintero García, I. *Seguimiento del comportamiento estructural de puentes durante su vida útil.* **Jornada sobre Gestión, Seguimiento y Reparación de Puentes.**

Castillo, F. *Coordinación de la sesión: La Seguridad Vial y la Infraestructura.* **VI Jornada sobre Barreras Metálicas de Seguridad.**

Compte, A. *Presentation on PIARC and its TC A.3 activities.* **International seminar on implemented and envisaged road toll policies in the Central-Eastern European countrie.**

Cordero, M.D. *Aliviadero de la Presa de Huesna.* **Seminario de PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos).**

Cordero, M.D. *Aliviadero en laberinto en la Presa de María Cristina.* **Seminario de la PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos).**

Corestein, G.; Bladé, E.; Olivares, G.; Dolz, J.; Pascual, P.; Aramburu, E. y Lara, Á. *Estudio en modelo matemático del río Tiétar.* **Seminario de la PTLHE. Líneas prioritarias A (Criterios hidromorfológicos para la recuperación de espacios fluviales degradados) y B (Hidrodinámica de embalses. Gestión sostenible).**

Cristóbal, E.; Justel, A.; Toro, M. y Velasco, S. *Tolerancia y óptimos robustos de taxones en estudios de limnología.* **XII Conferencia Española de Biometría, CEB 2009.**

Cuadra, A.; Rodríguez, M.; Ruiz, J.M.; Casas, T. y Rivas, J.A. *Control de Plataformas ferroviarias con Geo-Rádar.* **3as Jornadas Hispano-Portuguesas de Geotecnia.**

Cuéllar, V.; Rodríguez-Plaza, M.; Valerio, J. y Lozano del Moral, A. *Track transition zones. Infrastructure or superstructure problem?* **INNOTRACK seminar with focus on sub-structure.**

Cuéllar, V.; Valerio, J.; Rivas, J.A. y Rodríguez, M. *Improvement of transition zones for an old embankment.* **17 th International Conference on Soil Mechanics and Geotechnical Engineering**

Dapena, E. *Spanish Technical Regulations or Road Construction.* **2nd International Seminar Earthworks in Europe.**

Dapena, E.; Pardo de Santayana, F. y Díaz-Flores; E. *Characteristics of phosphogypsum for utilisation in roadwork fills.* **17 th International Conference on Soil Mechanics and Geotechnical Engineering.**

Dapena, E.; Pardo de Santayana, F. y Díaz-Flores, E. *Characteristics of phosphogypsum for utilisation in roadwork fills.* **17 th International Conference on Soil Mechanics and Geotechnical Engineering.**

Díaz Simal, P. *Auscultation Techniques on road Bridges.* **International Seminar on Concrete Bridges.**

Díaz Simal, P. y López Rodríguez, E. *Seguimiento de Puentes en Tiempo Real.* **Jornada sobre Gestión, Seguimiento y Reparación de Puentes.**

Estaire, J. *Estudios de tratamientos con cal de la plataforma ferroviaria de Alta Velocidad.* **Jornada Técnica ADIF-ANCADE.**

Estaire, J.; Serrano, L. y Navarro, J.J. *Estudios de tratamientos con cal de la plataforma ferroviaria de alta velocidad.* **3as Jornadas Hispano-Portuguesas de Geotecnia.**

Fernández Prisuelos, J. y Montero Montalvo, J.M. *A 138.000 m³ LNG access study to the port of Ferrol through a narrow channel using a real time ship maneuvering simulator.* **International Conference on Marine Simulation and Ship Maneuverability (MARSIM09).**

Flores, C.; Villén, L.; Rivera, J.; Alonso, A.M.; Rivera, J. y Caixach, J. *Aplicación de la espectrometría de masas (LC/ESI-MS/MS y H-SRM) a la determinación de microcistinas.* **1° Congreso Ibérico de Cianotoxinas. III Reunión de estudios en cianotoxinas.**

García Cantón, A. *Overview of quantity and quality water management in Spain.* **5th World Water Forum.**

García Cantón, A. *Tools for water planning.* **5th World Water Forum.**

García Cantón, A. *Water Quality in programmes of measures in river basin management plans in Spain.* **5th World Water Forum.**

González-Gallego, J.; García de la Oliva, J.L.; Moreno, J.; Andrés, J. y Castellana, J. *Estabilización de un gran paleodeslizamiento reactivado en el área de Furco (SALLENT DE GÁLLEGO).* **VII Simposio Nacional sobre Taludes y Laderas Inestables.**

Grassa Garrido, J. M.; Grau Albert, J.I. y Gutiérrez Serret, R.M. *Breakwater development in Spain. The last ten years.* Conferencia Inaugural. **Coast, Marine Structures and Breakwaters**.

Grassa, J.M. ; Gutiérrez-Serret, R.M.; Martín-Soldevilla, M.J.; Ruiz-Mateo, A. y Santás, J.C. *Usage Combinée des Modèles Physiques et Numériques dans le Cadre d'un Projet de Développement d'un Nouveau Port en Espagne.* **Colloque annuel de la Société Hydrotechnique de France.**

Gutiérrez Serret, R.M. y Lozano Pedroche, J. *Physical model tests for the development of new typologies of low reflection caissons for harbour structures: breakwaters and wharves.* **33rd IAHR Biennial Congress.**

Gutiérrez Serret, R.M.; Lozano, J.; Grau, J.I.; Noya Arquero, F.; Valdés, J.M. y Pérez Díaz, J.C. *Ensayo en modelo físico del tronco y el morro de la solución de proyecto del dique de abrigo del puerto exterior de Coruña en Punta Langosteira.* **X Jornadas Españolas de Costas y Puertos 2009.**

Haddad, B.; Pastor, M.; Palacios, D. y Muñoz, E. *A SPH Depth Integrated Model for Popocatepetl 2001 Lahar.* **European Geosciences Union General Assembly 2009.**

IAEA Congress. International Atomic Energy Agency Coordinated Research Project. Díaz Teijeiro, M.F. *Modelling the spatial distribution of stable isotopic composition in precipitation in Spain combining geographical and meteorological parameter.*

Iglesias, R. *Water reuse in Spain: data overview and costs estimation of suitable treatment trains.* **Innovative processes and practices for wastewater treatment and re-use in Mediterranean region (Innova-Med conference).**

Jiménez, A. *El mapa de caudales máximos en España. Base teórica y situación actual.* **Jornada de presentación del Mapa de caudales máximos en la cuenca hidrográfica del Tajo.**

Juárez Sanz, E. **IX Jornadas de la Sociedad Española para la conservación y estudio de los mamíferos.**

Lanza, V. y Alaejos, P. *Reacción álcali-sílice. Ensayo químico para la detección de áridos reactivos.* **II Congreso Nacional de Áridos.**

Lanza, V.; Alaejos, P. y García Calleja, M. A. *Petrografía y Reacción álcali-sílice. Metodología para la identificación y cuantificación de componentes reactivos en áridos de reacción rápida.* **VII Congreso Ibérico de Geoquímica** .

Lechuga, A. *Freak waves: A case study.* **European Geosciences Union General Assembly 2009.**

Lechuga, A. *Nonlinear Waves, Instabilities and Observational Data.* **European Geosciences Union General Assembly 2009.**

Lechuga, A. y Losada, J. *Playas de San Sebastian: Evolución pasada y posibles mejoras.* **X Jornadas Españolas de Costas y Puertos 2009.**

Lechuga, C. *Análisis del comportamiento de presas de escollera ante un vertido por coronación.* **Seminario de la PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos).**

Lechuga, C. *El Laboratorio de Hidráulica del CEDEX.* **5th World Water Forum**

Lechuga, C. *Las Guías técnicas sobre conducciones para el transporte de agua a presión y sobre depósitos para abastecimiento de agua potable. Otros trabajos normativos del CEDEX en la materia.* **5th World Water Forum.**

Lechuga, C. *Obtención de modelos analíticos mediante técnicas fotogramétricas de roturas de presas de escollera ante un vertido por coronación y de lechos de ríos.* **Seminario de la PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos)**.

Lechuga, C. y Balairón, L. *La Guía Técnica sobre Depósitos de Regulación.* **XXIX Jornadas de la Asociación Española de Abastecimientos y Saneamientos (Aeas).**

Leiro, A. *Introducción a los Geosintéticos.* **Jornada Técnica sobre Aplicación de Geosintéticos en Lineales.**

Leiro, A. **Jornada Técnica sobre Aplicación de Geosintéticos en Lineales.** (Director).

Leiro, A. *Presentación del Capitulo Español de IGS.* **Jornada Técnica sobre Aplicación de Geosintéticos en Lineales.**

Leiro, A. y Blanco, M. *Estudio de geosintéticos utilizados en tres sistemas de impermeabilización de embalses expuestos a medios básicos.*

X Congreso Latinoamericano de Patología de la Construcción. XII Congreso de Control de Calidad en la Construcción.

Lloret Capote, A. y Barrio Alvarellos, I. del. *Visor de cartografía marina del CEDEX. Aplicaciones y Bases de datos asociadas.* **Conferencia ESRI 2009.**

López, D. *Estudios calibración del modelo SPH empleando datos de presión de prototipo del cuenco de amortiguamiento de la presa de Villar del Rey.* **Seminario de la PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos)**.

López, D. *Problemas de evacuación de aire durante la maniobra de compensación de presiones para la apertura del desagüe de fondo de la presa de la Viñuela.* **Seminario de la PTLHE. Líneas prioritarias C (Riesgo asociado a la escorrentía urbana) y D (Seguridad de presas. Aspectos hidrológicos e hidráulicos).**

López, D.; Marivela, R.; Lara A. y Pena L. *Applications of the SPH model to the design of Fishways.* **33rd IAHR Biennial Congress.**

López, D.; Marivela, R.; y Aranda, F. *SPH Model calibration using data from pressure of the prototype still basin of Villar del Rey dam, Spain.* **33rd IAHR Biennial Congress.**

Lorenzo, A.; Parra, L. *The use of CUBE GIS functionalities in the development of the Spanish national transport model.* **Futura Europe 2009 Citilabs European User Conference.**

Luis Fonseca, R.; Raimat, C.; Torrebadella, J.; Altmir, J.; Amigó, J. y González-Gallego, J. *Análisis comparativo entre la norma Suiza (FOEN) y la recomendación ETAG-27, para la homologación de kits de Barreras de Protección contra desprendimientos de rocas.* **VII Simposio Nacional sobre Taludes y Laderas Inestables.**

Magdaleno Mas, F. *Restauración de bosques de ribera* **I Congreso Colombiano de Restauración Ecológica.**

Magdaleno, F. y Martínez Romero, R. *Protocols of CEDEX for the assessment of hydrogeomorphological quality in rivers.* **International Seminar Physical Habitat Assessment Methods in Rivers.**

Marivela, R.; López, D.; García, J.L. y Arrazola, J. F. *Aplicaciones del SPH al diseño de escalas de peces.* **XIII Congreso Forestal Mundial.**

Marrón, J.O.; Rubio, B. y otros. *Comportamiento de las mezclas asfálticas frente a los nuevos métodos de ensayo incluidos en el marcado CE.* **XV Congreso Ibero-Latino Americano do Asfalto (CILA).**

Martín, D.; Verdugo, M.; Villén, L.; Hoyos C. de; Conde, L. y Avilés, J. *Estudio de toxicidad en embalses de las cuencas del Duero, Tajo y Guadiana en el 2008.* **1º Congreso Ibérico de Cianotoxinas. III Reunión de estudios en cianotoxinas.**

Martínez Etayo, L. *La información sobre tarifas y precios del agua en España: cómo se ha implementado en Hispagua.* **13th SEMIDE/EMWIS Steering Committee meeting.**

Martínez Etayo, L. *SIAGUA, Water Information System in Latin American.* **5th World Water Forum.**

Martínez, M. T.; Castillo, F.; Pons, A. y Campos, J. *Diferencias de color en medidas de materiales retrorreflectantes fluorescentes.* **IX Reunión Nacional de Óptica.**

Martínez-Gil Pardo de Vera, M.; Zorzo Gallego, P.; Lloret Capote, A. y otros. *Catálogo de medidas orientadas al cumplimiento de objetivos ambientales en aguas costeras y de transición.* **X Jornadas Españolas de Costas y Puertos 2009.**

Mateos, A. *Accelerated Pavement Testing for Warm Asphalt Mixtures.* **International Workshop on Cold and Warm Asphalt Mixture Design/Characterization and Pavement Design.**

Mateos, A. *El Ensayo Acelerado de Firmes como Herramienta de Investigación en Carreteras.* **IV Simposio Internacional de Avaliação de Pavimentos e Projetos de Reforço.**

Mateos, A. *Firmes de Larga Duración.* **Jornada sobre el Proyecto Fénix: Investigación en Carreteras más Seguras y Sostenibles.**

Mateos, C.; Elviro, V. y Cordero, M.D. *Regulatable siphon spillway (Aliviadero en sifón regulable).* **XXIII International Congress on Large Dams.**

Mateos, C.; Elviro, V. y Cordero, M.D. *The prevention of cavitation in siphons (La prevención de la cavitación en sifones).* **33rd IAHR Biennial Congress.**

Montero Montalvo, J.M. y Fernández Prisuelos, J. *Simulación del acceso y la salida en condiciones operativas exigentes de buques de carga rodada en el puerto de Santander.* **X Jornadas Españolas de Costas y Puertos 2009**.

Moral, A.; Esteras, S.; Ortega, N. *Ensayo de lixiviación según la norma UNE-EN 1744-3. Experiencias del ensayo en el Centro de Estudios del Transporte.* **II Congreso Nacional de Áridos.**

Mosteiro, L. *Gestion des métadonnées et référenciels de données sur l'eau.* **9th NFP Coordination Seminar of SEMIDE/EMWIS.**

Núñez, I.; Domínguez, A.; Villén, L.; Aguirre, M.; Alonso, C.; Ramón-Laca, C. y Alonso, A.M. *Caracterización hidroquímica y calidad de las aguas subterráneas de las Confederaciónes Hidrograficas del Cantábrico y Miño-Sil.* **7º Congreso Ibérico y X Congreso Nacional de Geoquímica.**

Ortega, E, y Batanero, G. *Fiabilidad y eficacia de las tecnologías de regeneración y sus costes asociados.* **IV Jornadas Técnicas sobre Tratamiento de Aguas Residuales.**

Ortega, E. *La reutilización de efluentes depurados en España. Perspectivas, oportunidades y barreras.* **Jornadas sobre la gestión pública del agua ante los desafíos del siglo XXI.**

Parra, L.; Santana, M.; Estaire, J. y L. Serrano, L. *Análisis de varios pliegos, normativas y recomendaciones de suelos tratados con cal.* **3as Jornadas Hispano-Portuguesas de Geotecnia.**

Pastor, M. et al. *A coupled, depth integrated model for dilatant viscoplastic cohesive-frictional mobilized soils: applications to fast catastrophic landslides.* Invited lecture. **Scientific Conference From Shear Bands to Rapid Flow.**

Pastor, M.; Mira, P.; Fernández-Merodo, J.A.; Herreros, M.I.; Mabssout, M.; López Querol, S.; Manzanal, D.; Haddad, B.; Blanc, T.; Pastor, M.J.; Drempetic, V.; Sánchez, M. y Álvarez, C. *Modelling of geological risks: an engineering approach. Invited lecture.* **International Symposium. Mathematical Simulation in Science and Technology.**

Payeras, J. y Pujol, L. *Visión general del índice de actividad alfa total en las aguas superficiales españolas.* **XVII Congreso nacional de Sociedad Española de Física Médica** y **XII Congreso nacional de Sociedad Española de Protección Radiológica.**

Peña, J.M. de la; Díez, G., Sánchez, F.J. e Iglesias, J. *Influencia de los estados límites de una playa en la ordenación del territorio: Caso de la playa de S'Abanell.* **X Jornadas Españolas de Costas y Puertos 2009.**

Perelli, M. *Presentación de la aplicación de inventario e incidencias en los túneles de la RCE.* **Jornada de presentación de la aplicación BIT para los responsables de seguridad de túneles de gestión directa de la RCE.**

Perelli, M. *Presentación de la aplicación de inventario e incidencias en los túneles de la RCE.* **Jornada de presentación de la aplicación BIT para los responsables de seguridad de túneles de gestión directa de la RCE.**

Pérez, J; Cadavid, B.; Mateos, A. *Managing data from instrumentation in the CEDEX test track.* **26th International Symposium on Automation and Robotics in Construction (ISARC).**

Perucho, Á; Díez, J.A.; Martínez, J.M. y Martínez Santamaría, J.M. *Deslizamiento producido en el terraplén situado en el tramo Encinas Reales (Norte)-Encinas Reales (Sur) de la Autovía de Málaga A-45, N-331 de Córdoba a Málaga.* **VII Simposio Nacional sobre Taludes y Laderas Inestables.**

Plaza Arroyo, M.; Diez Donoso, M.; Obispo Esteban, R. y Ruiz Mateo, A. *Optimization of a method to measure the effectiveness of dispersants.* **INTERSPILL 2009.**

Potenciano, Á. y Villaverde, J.J. *Implementación del modelo hidrológico de Témez para la evaluación de recursos hídricos con GRASS GIS. Fase superficial y subterránea.* **III Jornadas de SIG Libre.**

Potenciano, Á.; Barranco, L.M. y Álvarez, J. *Maximum daily rainfall changes in Spain for the 21st Century.* **11th Plinius Conference on Mediterranean Storms. EGU Topical Conference Series.**

Prendes Rubiera, N. *Evaluación del riesgo de Inundación de la franja costera española. Metodología y estudios previos.* **X Jornadas Españolas de Costas y Puertos 2009.**

Primer Congreso Internacional de Ingeniería Forense (INGEFOR).
Sáinz de Cueto Torres, F.J. *La Ingeniería Forense en*

relación con el Ciclo de Vida Útil de la Construcción. Jornadas de divulgación: 16 y 23 de febrero y 12 de marzo de 2009.

Quesada, A.; Camacho, A.; Fernández-Valiente, E.; Rochera, C.; Justel, A.; Toro, M.; Rico, E. y Bañón, M. *Maritime Antarctic lake dynamics in three years under different climatic conditions.* **ASLO Aquatic Sciences Meeting.**

Redondo Redondo, L.; Baonza González, A. y Gutiérrez Serret, R.M. *Estudio en modelo físico de la influencia de la longitud del dique de abrigo, en la operatividad de un atraque de la ampliación del puerto de Castellón.* **X Jornadas Españolas de Costas y Puertos 2009.**

Romero Muñoz, D. *Recursos documentales para el estudio histórico del territorio.* **Jornadas sobre la construcción del territorio en América.**

Romero Muñoz, D. *Urbanismo e ingeniería ilustrados en los arsenales de la Armada. Siglo XVIII.* **Seminario Internazionale di Studio-Seminario Internacional de Estudio.**

Rubio, B. *Compactación de probetas y determinaciones de densidad.* **Jornada Técnica sobre mezclas bituminosas.**

Rubio, B. *Coordinador de la sesión: Innovaciones en suelos y firmes.* **XX Symposium nacional de vías y obras de administración local. VII Congreso nacional de carreteras locales.**

Rubio, B. *Materiales: áridos y emulsiones.* **Jornada Técnica sobre lechadas bituminosas y microaglomerados en frío.**

Rubio, B. y Jiménez, R. *Assessment of moisture effect on porous mixtures and asphalt concrete for very thin layers using water sensitivity and Cántabro after immersion tests.* **7th International RILEM Symposium on Advanced Testing and Characterization of Bituminous Materials.**

Ruiz Arriaga, S. **Jornada sobre Evaluación de Impacto Ambiental de las infraestructuras en el medio natural.**

Ruiz Arriaga, S. **VI Conferencia sobre Gestión del Agua, AQUA 09.**

Ruiz Mateo, A. *Condicionantes ambientales de la explotación energética del medio marino.* **Jornada sobre nuevas energías en el mar. Aspectos tecnológicos y de negocio.**

Ruiz Mateo, A. *Empleo de los modelos físicos en el estudio de la dispersión de salmueras.* **Jornada internacional sobre avances tecnológicos en el diseño y control del vertido de salmueras en el medio marino.**

Sánchez de Juan, M. *Tarea 2.2. "Reciclado de RCD´s como áridos de hormigones no estructurales (hormigón in situ)".* **Jornada de presentación de las Tareas 2.1 y 2.2 del Proyecto CLEAM.**

Sánchez de Juan, M. y Alaejos P. *Construction of a cable-stayed bridge with recycled concrete in Valencia (Spain).* **2nd International RILEM Conference: Progress of Recycling in the Build Environment.**

Sánchez, F.J. y Peña, J.M. de la *Recomendaciones de diseño de diques exentos en las costas españolas.* **X Jornadas Españolas de Costas y Puertos 2009.**

Sánchez, J.F. *Submerged groins under grazing wave attack.* **33rd IAHR Biennial Congress.**

Sanjuán, E. Coordinador *II Traffic Session.* **ECTRI-FEHRL-FERSI Young Researchers Seminar 2009.**

Santana, M. y Estaire, J. *Análisis de la influencia de la helada en suelos tratados con cal.* **3as Jornadas Hispano-Portuguesas de Geotecnia.**

Santana, M. y Estaire, J. *Análisis de la influencia de los sulfatos en suelos tratados con cal.* **3as Jornadas Hispano-Portuguesas de Geotecnia.**

Santás, J.C. y Peña, J.M. de la. *New requirements on beach design: limiting states condition.* **Coastal Processes 2009 International Conference.**

Santiago Recuerda, E.; García de la Oliva, J.L. y González Paniagua, P. *Comparación de diferentes métodos de control de compactación del subbalasto.* **3as Jornadas Hispano-Portuguesas de Geotecnia.**

Segués, F. *El plan de acción contra el ruido PAR (2008–2012) de la Dirección General de Carreteras del Ministerio de Fomento.* **TECNIACÚSTICA 2009. 40º Congreso Nacional de Acústica - Encuentro Ibérico de Acústica.**

Segués, F. *Los Planes de Acción de las infraestructuras del transporte competencia del Ministerio de Fomento.* **Jornada de presentación del Mapa estratégico de ruido del municipio de Zaragoza.**

Segués, F. *Results of the first round of the strategic noise maps in Spain and actions derived.* **EURONOISE 2009.**

Soares, J.; Mateos, A.; Jiménez, R. y Marrón, J.O. *Estudio sobre ensayos de vida a fatiga en mezclas asfálticas por métodos adoptados en España y Brasil.* **IV Simposio Internacional de Avaliação de Pavimentos e Projetos de Reforço.**

Sordo, A.; Garrote, L.; Jiménez, A. y González-Zeas, D. *Estimation of the distribution of reservoir peak outflows from the distribution of peak inflow data and reservoir characteristics.* **33rd IAHR Biennial Congress.**

Sordo, A.; Jiménez, A.; Garrote, L. y Martín-Carrasco, F. *Should we use peak discharge or hydrograph volume and shape in the probabilistic design of dam spillways?* **European Geosciences Union General Assembly 2009.**

Soriano, J.; La Iglesia, A,; Garcia-Calleja, M. A. y López-Ruiz, J. *Reactividad potencial de las rocas andesíticas de Cabo de Gata.* **VII Congreso Ibérico de Geoquímica.**

Tamarit, J. **ERTMS high level roundtable.**

Tamarit, J. **Primeras Jornadas Ferroviarias.**

Tamarit, J. **UIC ERTMS World Conference "On Board and On Track".**

Varela Nieto, J.M. y García Sánchez-Colomer, M. **III Jornadas sobre Gestión municipal de control de plagas y su repercusión en la salud pública.**

Varela Nieto, J.M. y García Sánchez-Colomer, M..**V Congreso Nacional de Evaluación de Impacto Ambiental (V CONEIA).**

Vegas, I.; Lisbona A., Sánchez de Juan M. y Carvajal, M.D. *Characterization of Mixed recycled aggregates for use in non-structural concrete: influence of the treatment process.* **2nd International RILEM Conference: Progress of Recycling in the Build Environment.**

Velasco, A.; Alaejos, P. y Soriano, J. *Diferencias en la velocidad de la reacción álcali-sílice en áridos graníticos.* **VII Congreso Ibérico de Geoquímica** .

Velázquez, D.; Rochera, C.; Toro, M.; Chicote, A.; Justel, A.; Camacho, A. y Quesada, A. *Seasonal dynamic of different Antarctic water bodies.* **ASLO Aquatic Sciences Meeting.**

Villén, L.; Aguirre, M.; Alonso, C.; Domínguez, J.; Núñez, I.; Ramón-Laca, C. y Alonso A.M. *On-line preconcentration and liquid chromatography-tandem mass spectrometry method for the analysis of microcystins in natural waters.* **IX Reunión Científica de la SECYTA.**

Villén, L.; Flores, C.; Dominguez, J.A.; Alonso, A.M.; Caixach, J. y Avilés, J. *Determinación e identificación de cianotoxinas en aguas de embalses españoles.* **1º Congreso Ibérico de Cianotoxinas. III Reunión de estudios en cianotoxinas**

CEDEX PUBLICATIONS

INGENIERÍA CIVIL MAGAZINE

Almazán Gárate, J.L.; Matías Mateos; Á.; Parada González, A.; Martín Jiménez, J.; Iribarren Lasconateguy, E. y Amorós Serret, J.R. *Análisis de movimientos y aceleraciones provocados por las acciones del oleaje y de los buques en el dique de Botafoc (Ibiza).* Ingeniería Civil. 2009, nº 153, p. 15-26.

Blanco, M. y Leiro, A. *Comportamiento de un geosintético utilizado en el drenaje de un embalse.* Ingeniería Civil. 2009, nº 153, p. 29-35.

Blanco, M.; Aguiar, E.; Vara, T.; García, F.; Soriano, J. y Castillo, F. *Comportamiento de geomembranas sintéticas instaladas en el campo experimental de El Saltadero.* Ingeniería Civil. 2009, nº 153, p. 37-44.

Blanco, M.; Rico, G.; Pargada, L.; Aguiar, E. y Castillo, F. *Determinación de los ftalatos utilizados como aditivos en la geomembrana de la balsa de La Florida mediante cromatografía de gases-espectrometría de masas.* Ingeniería Civil. 2009, nº 154, p. 87-95.

Carrasco García, M.J.; Enríquez de Salamanca, Á.; Varela Nieto, J.M. y Magdaleno Mas, F. *Gestión y restauración de zonas de préstamos y vertederos en obras civiles.* Ingeniería Civil. 2009, nº 155, p. 31-46.

Crespo García, L. *La movilidad urbana: un gran reto para las ciudades de nuestro tiempo.* Ingeniería Civil. 2009, nº 154, p. 97-106.

Crespo García, L. y Portillo Jiménez-Landi, A. *Estrategias del sector del transporte y su impacto en la calidad del aire y en los gases de efecto invernadero.* Ingeniería Civil. 2009, nº 153, p. 45-52.

Díaz-Teijeiro, M.F.; Rodríguez-Arévalo, J. y Castaño, S. *La red española de vigilancia de isotopos en la precipitación (REVIP). Distribución isotópica espacial y aportación al conocimiento del ciclo hidrológico.* Ingeniería Civil. 2009, nº 155, p. 87-97.

Dimas Suárez, M.; Bejarano Vinagre, M.A.; Espina Argüello, A.; Quintas Ripoll, L.; Martínez García, S. y Pastor Argüello, F. *Descripción del Anuario de Aforos 2005-2006. Confederaciones hidrográficas y tratamiento de los datos.* Ingeniería Civil. 2009, nº 153, p. 75-83.

García Mañes, M. y Martín Soldevilla, M.J. *Caracterización de posibles fenómenos de resonancia en la futura dársena exterior de Levante del puerto de Málaga mediante modelación numérica.* Ingeniería Civil. 2009, nº 153, p. 55-63.

López Ramos, S. *Control de calidad en los ensayos de sistemas de contención de vehículos. Intercomparación de los resultados de los ensayos.* Ingeniería Civil. 2009, nº 153, p. 99-109.

Lozano Valero, I.; Palacios García de la Rosa, D.; Doncel Moratilla, A; Iglesias Pérez, L.; Ortega Santos, L.; Varela Nieto, J.M. y García Sánchez-Colomer, M. *Criterios ambientales a incorporar en proyectos de ingeniería civil para favorecer el procedimiento de evaluación de impacto ambiental.* Ingeniería Civil. 2009, nº 154, p. 37-56

Marrón Fernández, J. O.; Rubio Guzmán, B. y Pérez Ayuso, F.J. *Ensayo español interlaboratorios de pista.* Ingeniería Civil. 2009, nº 154, p. 59-70.

Mateos Moreno, Á.; Marrón Fernández, J.O. y Pérez Ayuso, J. *Firmes de larga duración.* Ingeniería Civil. 2009, nº 155, p. 49-57.

Muñoz Alvarado, F. y Sotillo Membibre, M. *Estudio comparativo del temporal de los días 10-11 de marzo 2008.* Ingeniería Civil. 2009, nº 154, p. 73-84.

Navarro Sáez, A.; Martín Soldevilla, M.J y Alfonso, M. *Estudio de transferencia de información entre la red exterior de oleaje y la red costera. Matrices de transferencia en el punto de Langosteira.* Ingeniería Civil. 2009, nº 153, p. 65-74.

Peña Olivas, J.M. de la. *Pautas para el análisis de problemas costeros.* Ingeniería Civil. 2009, nº 155, p. 99-109.

Pujol, L.; Lara-Calleja, S.; Suárez-Navarro, M.J. y González-González, J.A. *Estudio de un sistema de detección tipo pórtico para su aplicación en la industria del metal.* Ingeniería Civil. 2009, nº 153, p. 91-98.

Rubio Guzmán, B. y Jiménez Sáez, R. *Determinación del contenido de betún y de caucho en las mezclas bituminosas que incorporan polvo de caucho procedente de neumáticos fuera de uso.* Ingeniería Civil. 2009, nº 155, p. 59-68.

Santiago Buey, C. de y Pardo de Santayana Carrillo, F. *Aprovechamiento de la energía geotérmica superficial en la obra pública.* Ingeniería Civil. 2009, nº 156, p. 102-112

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ISBN 978-84-7790-511-0.

Bermúdez Odriozola, M. A. y Alaejos Gutiérrez, M. P. *Estudio experimental de la durabilidad del hormigón armado en ambiente marino. Zonas sumergidas y de carrera de mareas.* Colección Monografías CEDEX M103.
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CEH. *Guía técnica sobre tuberías para el transporte de agua a presión.* 6ª edición. Colección Manuales y Recomendaciones CEDEX R-13. ISBN 978-84-7790-492-2.

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Enríquez de Salamanca, A. y Carrasco García, M.J. *Manual de gestión y restauración de zonas de préstamos y vertederos en obras civiles.* Colección Manuales y Recomendaciones CEDEX R-19. ISBN 978-84-7790-485-4.

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GENERAL SECRETARIAT

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GENERAL DIRECTORATE OF ROADS

Asesoramiento para la actualización del capítulo 2 de la norma 5.2. IC de Drenaje superficial. *(Informes: 1)*

Asistencia en materia geotécnica a la Dirección General de Carreteras del Ministerio de Fomento. *(Informes:21)*

Ensayo sobre explanadas en la pista de firmes a escala real del CEDEX. *(Informes: 1)*

Estudio histórico de los datos de básculas dinámicas y optimización de su empleo en conjunción con la Red de Aforos de Tráfico. *(Informes: 1)*

Estudios y trabajos de carácter especial en temas de patología de puentes y estructuras. *(Informes: 1)*

Evaluación comparativa de medidas tomadas con distintos equipos de auscultación de firmes. *(Informes:2)*

Evaluación comparativa de medidas tomadas con distintos equipos de medida de características superficiales de los pavimentos. *(Informes: 1)*

Identificación de ámbitos prioritarios para la asistencia técnica, investigación y desarrollo a promover entre la DGC y el CEDEX en 2009-2015. *(Informes: 1)*

Propuesta de recomendaciones para el proyecto y construcción de firmes y pavimentos para túneles. *(Informes: 1)*

Propuesta de un manual para la construcción de transiciones terraplén-tablero de puente. *(Informes: 1)*

Realización de tareas de evaluación de patologías de puentes y estructuras de carretera. *(Informes:9)*

GENERAL DIRECTORATE OF THE MERCHANT NAVY

Apoyo en la tramitación de solicitudes de homologación de productos para la lucha contra la contaminación por hidrocarburos. *(Informes:4)*

Apoyo en relación con los convenios auspiciados por la OMI. *(Informes:4)*
Apoyo en relación con los convenios OSPAR y Barcelona *(Informes: 1)*

Asistencia técnica permanente en materias relacionadas con la seguridad marítima y la protección del ecosistema marino. *(Informes: 1)*

Estudio de condiciones de clima marítimo en el transcurso de accidentes de buques. *(Informes:9)*

Estudios de simulación de maniobras en zonas exteriores de puertos. Análisis de las condiciones meteorológicas límite de permanencia de buques fondeados en la bahía de Algeciras. *(Informes: 1)*

Participación, en los años 2008, 2009 y 200, en los ejercicios de intercomparación del Convenio de Bonn. *(Informes: 2)*

Recopilación de las condiciones climáticas históricas existentes en el transcurso de accidentes de buques en las rutas de navegación española. Fase II. *(Informes: 1)*

Trabajos analíticos encaminados a la identificación de culpables en casos de derrames de hidrocarburos desde buques *(Informes:4)*

RAILWAY INFRASTRUCTURES ADMINISTRATOR (ADIF)

Análisis de la instrumentación dispuesta en el puente de Candí y propuesta de ampliación y/o de ensayos complementarios. *(Informes:3)*

Análisis de procedimientos de tratamientos con cal de la plataforma ferroviaria de alta velocidad. *(Informes:6)*

Estudio del subbalasto bituminoso y aspectos del balasto mediante la realización de ensayos acelerados a escala real en la instalación del CEDEX. *(Informes:5)*

Instrumentación y medida del comportamiento de tres viaductos de líneas de alta velocidad. *(Informes:7)*

Procedimientos para la auscultación de plataformas ferroviarias con georradar. *(Informes:2)*

Seguimiento del comportamiento de secciones de vía de alta velocidad mediante técnicas de instrumentación. *(Informes:2)*

Seguimiento y asesoramiento geotécnico para la adopción de métodos constructivos en el túnel El Regajal del nuevo acceso ferroviario de alta velocidad a Levante. *(Informes: 1)*

Soluciones constructivas en zonas de transición para optimizar el cambio de rigidez de la plataforma. *(Informes:2)*

Validación de un método continuo de comprobación del grado de compactación y del módulo de deformación del subbalasto. *(Informes: 1)*

STATE PORTS

Actualización de las condiciones de diseño en el emplazamiento del puerto de Pasajes. *(Informes: 1)*

Análisis de la deformabilidad de escolleras utilizadas en las banquetas de cimentación de cajones portuarios. *(Informes: 1)*

Análisis de las cadenas de transporte internacional de mercancías que se apoyan en puertos españoles, enfocado a la identificación de orígenes, destinos y encaminamientos. *(Informes: 1)*

Apoyo metodológico al cumplimiento de la Directiva Marco del Agua. *(Informes: 1)*

Asistencia geotécnica permanente a los puertos del Estado. *(Informes: 1)*

Asistencia geotécnica permanente a los puertos del Estado. Año 2009. *(Informes:6)*

Asistencia técnica a la Autoridad Portuaria de Bilbao para la medida de oleaje direccional en el abra de Bilbao. Fase 2008. *(Informes: 1)*

Asistencia técnica permanente en materias ambientales (2009). *(Informes: 1)*

Campaña de medida de oleaje direccional al sureste del islote de Escombreras. Fase 2008. *(Informes: 1)*

Campaña de medida de oleaje en la zona de Granadilla (Tenerife). Fase 2008. *(Informes: 1)*

Campaña de medida y análisis de oleaje en el puerto de Melilla. Fase 2008. *(Informes: 1)*

Campaña de medida y análisis de ondas largas en la dársena interior del puerto de Tarragona. Fase 2008. *(Informes: 1)*

Estudio del comportamiento del hormigón de pantalanes y cajones portuarios. *(Informes: 1)*

Inventario de dragados en los puertos españoles. Actualización 2008. *(Informes: 1)*

Investigación sobre bioensayos para la caracterización del material dragado. *(Informes: 1)*

Metodología para la determinación del nivel de servicio de muelles por condiciones hidrometeorológicas. *(Informes: 1)*

Metodología racional para el estudio de cimentaciones de obras marítimas. *(Informes: 1)*

Modelado numérico avanzado de dinámica de fluidos. *(Informes: 1)*

Modelos probabilistas de fiabilidad de estructuras. *(Informes: 1)*

Puerto de Barcelona. Estudio de maniobra en la dársena nacional. *(Informes: 1)*

Puerto de Bilbao. Actualización del cálculo de los oleajes de diseño en los diques del puerto. Ampliación a los sectores NNW, N y NNE. *(Informes: 1)*

Puerto de Bilbao. Estudio de maniobra de buques en el muelle de cruceros en el abra interior. *(Informes: 1)*

Puerto de Cádiz. Estudio en modelo físico 3D de agitación y barcos atracados de la nueva terminal de contenedores. *(Informes: 1)*

Puerto de Castellón. Estudio de maniobrabilidad de los buques en el canal de navegación del puerto. *(Informes: 1)*

Puerto de Ferrol. Análisis de la flota de metaneros en relación con el acceso a la terminal de Reganosa, en Mugardos (ría de Ferrol). *(Informes: 1)*

Puerto de Huelva. Estudio de los medios y recursos necesarios para la lucha contra la contaminación marina accidental en el puerto. *(Informes: 1)*

Puerto de La Coruña. Estudio de las fases constructivas en el tramo principal del dique del puerto exterior. *(Informes: 1)*

Puerto de Las Palmas. Ensayo en modelo físico 3D del entronque entre el tramo en talud y el vertical del dique de La Esfinge. *(Informes: 1)*

Puerto de Las Palmas. Estudio de agitación en la dársena de La Esfinge. *(Informes: 1)*

Puerto de Las Palmas. Estudio de condiciones de oleaje de diseño de las obras de la zona de La Esfinge. *(Informes: 1)*

Puerto de Tarragona. Estudio de alternativas para una nueva dársena exterior. *(Informes: 1)*

Puerto de Valencia. Ensayos 3D de la modificación de la berma del dique de la ampliación del puerto con incidencia oblicua. *(Informes: 1)*

Puerto de Valencia. Ensayos 3D, con oleaje oblicuo, del tramo en talud del dique de la ampliación del puerto: sección tipo, transición del tramo en talud al vertical y arranque en la dársena de la America's Cup. *(Informes: 1)*

Puerto de Valencia. Ensayos en modelo físico 3D de agitación y barcos atracados de la ampliación del puerto de Sagunto. *(Informes:2)*

Puerto de Villagarcía. Seguimiento ambiental de las obras de dragado y vertido, y caracterización de los sedimentos en el puerto. *(Informes:2)*

Puertos de Baleares. Estudio de maniobras de buques para la determinación de las características del remolcador de Mahón y límites operacionales actuales. *(Informes: 1)*

REMRO 1 de enero de 2008 a 31 de diciembre de 2008. *(Informes: 1)*

RENFE OPERADORA INECO

Apoyo técnico a Renfe-Operadora en la formación de personal en el sistema europeo ERTMS. *(Informes: 1)*

Acuerdo de adhesión al proyecto GRAIL (GNSS Introduction in the Rail Sector), dentro del contrato GJU/05/2409/CTR/GRAIL (firmado entre Galileo Joint Undertaking e Ingeniería y Economía del Transporte-INECO-) *(Informes: 1)*

MINISTRY OF THE ENVIRONMENT AND RURAL AND MARINE AFFAIRS

GENERAL DIRECTORATE OF ENVIRONMENTAL QUALITY AND EVALUATION

Actualización del catálogo de residuos utilizables en la construcción. *(Informes: 1)*

Actualización, mantenimiento y explotación del sistema básico de información sobre el ruido. *(Informes: 1)*

Asistencia técnica en la evaluación de impacto ambiental de vertidos líquidos y de actuaciones en el medio marino. *(Informes: 10)*

Asistencia técnica en temas de evaluación de impacto ambiental. *(Informes:6)*

Asistencia técnica para trabajos relacionados con la aplicación de la legislación en materia de ruido ambiental. *(Informes: 1)*

Asistencia técnica, investigación y desarrollo tecnológico en materia de evaluación ambiental estratégica (EAE). *(Informes:3)*

Creación y desarrollo de aplicaciones de consulta de un sistema de geodatos y declaraciones de impacto ambiental asociadas a infraestructuras situadas en los litorales mediterráneo, atlántico sur y canario. *(Informes: 1)*

Trabajos técnicos sobre residuos de actividades extractivas. *(Informes: 1)*

Utilización de cenizas volantes en terraplenes. *(Informes: 1)*

Utilización de escorias de incineradores urbanos en carreteras (II). *(Informes: 1)*

Utilización de las fracciones granulométricas finas de los áridos reciclados de hormigón. *(Informes: 1)*

GENERAL DIRECTORATE OF SUSTAINABILITY OF THE COAST AND THE SEA

Apoyo técnico para la redacción de los planes de cuenca en relación con la Directiva Marco de Aguas. *(Informes: 1)*

Colaboración en el convenio OSPAR. *(Informes:4)*

Condicionantes de la Posidonia oceánica en la atenuación del oleaje y las actuaciones costeras. *(Informes: 1)*

Ensayos sistemáticos en modelo físico a escala reducida de estructuras costeras. *(Informes: 1)*

Estudio de aspectos ambientales de actuaciones en diversos puntos del litoral español. *(Informes: 1)*

Estudio de la dinámica litoral en diversas playas del litoral español. *(Informes: 3)*

Estudio de perfiles de playa y su adaptación a las costas españolas. *(Informes: 2)*

Evaluación del impacto de instalaciones de energía eólica fuera de la costa. *(Informes: 1)*

Evaluación preliminar de las zonas costeras en riesgo de inundación en relación con la Directiva de Inundaciones. *(Informes: 1)*

Preparación de la estrategia marina española según las disposiciones de la Directiva Marina Europea. *(Informes: 1)*

Propuesta de embalse piloto para el aprovechamiento de sus sedimentos. *(Informes: 1)*

Seguimiento de la evolución ambiental y ecológica en zonas de dominio público marítimo-terrestre. *(Informes: 3)*

Seguimiento de la playa de El Espartal y Salinas (Avilés). Fase 2007-2009. *(Informes: 1)*

Seguimiento de la playa de La Zurriola (Guipúzcoa). Fase 2007-2009. *(Informes: 1)*

Seguimiento de la playa de Peñíscola (Castellón). Fase 2007-2009. *(Informes: 1)*

GENERAL DIRECTORATE OF WATER

Actualización de los ecotipos en las masas de agua superficiales y asistencia técnica en el diseño del sistema de clasificación del estado ecológico; condiciones de referencia y establecimiento de clases ecológicas: ríos, lagos y embalses. *(Informes: 1)*

Actualización e implementación de nuevas tecnologías en el Sistema Español de Información sobre el Agua HISPAGUA. *(Informes: 1)*

Acuíferos y zonas húmedas. *(Informes: 2)*

Aliviadero de San Calixto (Murcia). *(Informes: 1)*

Análisis del comportamiento de las presas de escollera en caso de un vertido por coronación. *(Informes: 1)*

Análisis radiológico de las aguas potables de consumo público de la red primaria que gestiona la Mancomunidad de los Canales del Taibilla (cuatro años hidráulicos). *(Informes: 1)*

Apoyo en actividades relacionadas UNESCO, Consejo Mundial del Agua (World Water Council), Oficina de la Década del Agua y diversas redes internacionales. *(Informes: 1)*

Asesoramiento en materias geotécnicas. *(Informes: 22)*

Asistencia técnica a la DGOHyCA para estudios de fugas de embalses. *(Informes: 8)*

Asistencia técnica a las evaluaciones ambientales (planes, programas y proyectos), medidas correctoras y compensadoras, seguimiento y vigilancia ambiental. *(Informes: 3)*

Auscultación de presas. *(Informes: 2)*

Desaladoras de agua de mar de Melilla y Ceuta. *(Informes: 1)*

Desaladoras de la Mancomunidad de los Canales del Taibilla. *(Informes: 1)*

Deterioro de los hormigones de presas. *(Informes: 1)*

Efecto del cambio climático en los recursos hídricos disponibles en los sistemas de explotación. *(Informes: 1)*

Ensayo en modelo reducido del aliviadero y los desagües de fondo de la presa de Villar del Rey (Badajoz). *(Informes: 1)*

Escala de peces en presas y azudes. *(Informes: 2)*

Estudio del aliviadero de la presa de Huesna (Sevilla). *(Informes: 1)*

Estudio en modelo físico reducido de la restauración hidromorfológica del río Narcea. Construcción parcial del modelo. *(Informes: 1)*

Estudio en modelo reducido de los aliviaderos de Calanda. Diseño y ensayo del morning glory. *(Informes: 1)*

Estudio en modelo reducido del desagüe del Júcar por el Estany de Cullera. *(Informes: 1)*

Estudio en modelo reducido del encauzamiento de los barrancos de Quisi y Pou Roig, en Calpe (Alicante). *(Informes: 1)*

Estudio en modelo reducido del encauzamiento del barranco de Andarax (Almería). Variante al proyecto. *(Informes: 1)*

Estudio metodológico sobre la definición y establecimiento de regímenes de caudales ambientales. *(Informes: 1)*

Explotación de áridos en un tramo fluvial. *(Informes: 1)*

Geomembranas sintéticas para impermeabilización de embalses. *(Informes:60)*

Identificación molecular de cianobacterias potencialmente productoras de toxinas, análisis de cianotoxicidad y bioensayo de toxicidad mediante nuevos métodos. Campaña 2008. *(Informes: 1)*

Ingeniería e impacto ambiental de instalaciones desaladoras. *(Informes: 2)*

Mantenimiento y actualización del Sistema Iberoamericano de Información del Agua SIAGUA. *(Informes: 1)*

Mejora de la operación coordinada de alivio controlado de crecidas de presas. *(Informes: 1)*

Normalización de obras hidráulicas. *(Informes: 1)*

Obras e instalaciones de saneamiento y depuración de aguas residuales urbanas. *(Informes: 8)*

Obras incluidas en el convenio MIMAM-Gobierno de Cataluña. *(Informes: 1)*

Otras obras incluidas en el convenio MIMAM-Gobierno de Baleares. *(Informes: 8)*

Participación en el Sistema Euro Mediterráneo de Información del Agua (SEMIDE/EMWIS) y en el mantenimiento de su Unidad Técnica. *(Informes: 2)*

Prevención de riesgos hídricos naturales e inducidos por obras hidráulicas. *(Informes: 2)*

Proyecto, instalación y mantenimiento de tuberías para el transporte de agua a presión. *(Informes: 1)*

Reconocimiento y estudio geotécnico. *(Informes: 1)*

Recopilación y difusión de información hidrometeorológica. *(Informes: 1)*

Red de Vigilancia Radiológica Ambiental de las aguas continentales españolas. Años hidráulicos 2006-2007, 2007-2008. *(Informes: 12)*

Redes de control de calidad de las aguas subterráneas. *(Informes: 1)*

Reutilización planificada de efluentes depurados. *(Informes: 2)*

Trabajos relativos a la presa de Amadorio (Alicante). *(Informes: 1)*

Tratamiento de lodos procedentes de la depuración de aguas residuales. Directiva 86/78/CEE. *(Informes: 1)*

AGUAS DE LAS CUENCAS MEDITERRÁNEAS, S.A. (ACUAMED)

Asistencia técnica para el diseño, construcción y vigilancia ambiental de los dispositivos de vertido al mar de efluentes líquidos. *(Informes: 1)*

MINISTRY OF CULTURE

MANAGEMENT OF INFRASTRUCTURE AND EQUIPMENT FOR CULTURE

Asistencia técnica de análisis de las patologías presentadas en determinados elementos estructurales del Patio de Bojes del Museo de Bellas Artes (Sevilla), incluyendo la redacción de un procedimiento constructivo de reposición. *(Informes: 1)*

Control de movimientos de la losa de forjado del Palacio del Infantado (Guadalajara) durante las pruebas de carga. *(Informes: 1)*

MINISTRY OF HOME AFFAIRS

TRAFFIC CENTRAL OFFICE

Elaboración de un manual práctico para las inspecciones de seguridad vial en carreteras en servicio en España. *(Informes: 1)*

MINISTRY OF JUSTICE

Informes periciales sobre la estabilidad geotécnica de la corta minera Cobre Las Cruces (Sevilla). *(Informes: 1)*

MICLEAR SAFETY COMMISSION

Asistencia técnica al Consejo de Seguridad Nuclear en los programas de vigilancia radiológica del medio acuático. Año 2009. *(Informes: 1)*

Programa de vigilancia radiológica ambiental en el medio acuático (Red de estaciones de muestreo: red espaciada). Año 2008. *(Informes: 1)*

FUNDACIÓN CIUDAD DE LA ENERGÍA (CIUDEN)

Asistencia técnica en el estudio geotécnico de dos escombreras situadas en Tremor de Arriba (León). *(Informes: 1)*

REGIONAL ADMINISTRATION

Realización de proyecto de mejora ambiental del meandro del Plantío (Mendigorría y Mañeru - Navarra). *(Informes: 1)*

SPANISH PRIVATE SECTOR

Asistencia técnica para la obra denominada Depósito superior de la central hidroeólica de El Hierro. *(Informes: 1)*

Ensayos de LEU de ELIOP, primera fase. *(Informes: 1)*

Estudio del diagnóstico de la patología del hormigón del túnel de Rivas. *(Informes: 1)*

Estudio hidráulico mediante modelo físico a escala reducida de la erosión localizada en las zapatas del puente de Vidin-Calafat en el río Danubio. *(Informes: 1)*

Estudio sobre la difusión de contaminantes en las barreras de vertederos urbanos y su evolución en el tiempo. *(Informes: 1)*

Realización de análisis del agua residual producida por el tratamiento de polímeros utilizados en cimentaciones especiales. *(Informes: 1)*

Realización de ensayos de contraste de los de seguimiento (2008) de armaduras de acero con marca ARCER. *(Informes: 1)*

Realización de ensayos de eficacia de los dispersantes AQ-11 y VER-QUIM2 (ALFQUIM 2011, S.L.). *(Informes: 1)*

Realización de pruebas de vibración y choque de cargador de 12 kW para coches del R44 (NYCT). Código SEPSA 020034. *(Informes: 1)*

Realización de pruebas de vibración y choque de cargador de 6,5 kW para coches del R62 (NYCT). Código SEPSA 020037. *(Informes: 1)*

Realización de pruebas de vibración y choque de cargador de 6,5 kW para coches del R62A (NYCT). Código SEPSA 020035. *(Informes: 1)*

Realización de pruebas de vibración y choque de convertidor estático. Código SEPSA 000463. *(Informes: 1)*

Realización de pruebas de vibración y choque de equipos para el proyecto CESIS 2008 RENFE. *(Informes: 1)*

Realización de pruebas de vibración y choque de equipos para el proyecto Renfe Media Distancia. *(Informes: 1)*

Realización de pruebas de vibración y choque de un convertidor estático de 209 kVA CPTM. IEC 61373. *(Informes: 1)*

Realización de pruebas de vibración y choque de un convertidor SEPSA 000450, equipado con cofre JIZHEN. *(Informes: 1)*

Realización de pruebas de vibración y choque del convertidor auxiliar MM 137 kVA bitensión. IEC 61373. *(Informes: 1)*

Realización de pruebas de vibración y choque del equipo 6,5 kW LVPS 462A (2ª Serie). IEC 61373. *(Informes: 1)*

Realización de un estudio sobre barreras geosintéticas bentoníticas. *(Informes: 1)*

Realización del asesoramiento en la dirección del modelo físico de la presa de Villalba de los Barros (Badajoz). *(Informes: 1)*

Reciclado de RCDs como áridos de hormigones estructurales. *(Informes: 2)*

Reciclado de RCDs como áridos de hormigones no estructurales. *(Informes: 2)*

Vigilancia radiológica del río Ebro, en torno a las instalaciones de la central nuclear de Santa María de Garoña (2008). *(Informes: 1)*

Vigilancia radiológica del río Ebro, en torno a las instalaciones de las centrales nucleares de Ascó (2008). *(Informes: 1)*

Vigilancia radiológica del río Tajo, en torno a las instalaciones de la central nuclear de Almaraz. Año 2008. *(Informes: 1)*

INTERNATIONAL SECTOR

Estudio de viabilidad de una instalación para ensayo acelerado de firmes en Argelia. *(Informes: 3)*

Realización de pruebas de vibración y choque de Flirt filter 50 Hz transformers (BDB Project). *(Informes: 1)*

Realización de pruebas de vibración y choque del equipo Desiro ScotRail Transformer. IEC 61373. *(Informes: 1)*

INTERNAL COLLABORATIONS

Colaboración (31-407-3-002). Seguimiento de tramos de ensayo con mezclas bituminosas fabricadas con polvo de caucho procedente de neumáticos fuera de uso (NFU) y terraplenes con neumáticos troceados. *(Informes: 1)*

Colaboración (80-406-4-010). Colaboración en los trabajos de estudio del subbalasto bituminoso y aspectos del balasto mediante la realización de ensayos acelerados a escala real en la instalación del CEDEX. *(Informes: 1)*

Colaboración (80-406-4-010). Coordinación y ayuda en la interpretación y realización de ensayos de mezcla bituminosa. *(Informes: 5)*

R+D+i PROJECTS

El uso de energías alternativas en España. Aprovechamiento energético del oleaje. *(Informes: 1)*

Ensayo de verificación de la precisión de los equipos de pesaje dinámico instalados en el PK 407+700 de la A-5, en la frontera con Portugal. *(Informes: 1)*

Proyecto de I+D+i. Convergencia de túneles en macizos viscoelastoplásticos. *(Informes: 1)*

Proyecto FÉNIX. Actividad 06. Pavimentos de larga duración. *(Informes: 1)*

Proyecto FÉNIX. Actividad 10. Empleo de subproductos. *(Informes: 1)*

Realización de recomendaciones para la ejecución del hormigonado de pilotes y pantallas in situ. *(Informes: 1)*

PROPIOS CEDEX

Servicio técnico permanente. Ensayos geotécnicos de laboratorio (2009). *(Informes: 1)*

COMMITTEES

Agencia Europea de Medio Ambiente. Grupo de trabajo de la *Reporting Mechanism Environmental Noise Directive*

Agencia Nacional de Evaluación de Proyectos (ANEP). Evaluador

ALERT Geomaterials. Comité de Dirección

American Society for Testing and Materials (ASTM)

ARCER. GT1. Características de tracción y fatiga

Asociación Científico-Técnica del Hormigón Estructural (ACHE). Comisión 2. Materiales GT 2.2. Cimentaciones especiales

Asociación Española de Abastecimiento y Saneamiento (AEAS). Comisión 4ª Drenaje urbano
Comisión 5ª Depuración de aguas residuales

Asociación Española de Desalación y Reutilización (AEDYR)

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CTC 15. Cementos
CTC 17. Productos de acero para hormigón
CTC 19. Báculos y columnas de alumbrado público
CTC 32. Impermeabilizantes bituminosos
CTC 33. Dispositivos de cubrimiento y de cierre
CTC 36. Tubos y perfiles huecos de acero
CTC 46. Perfiles de acero laminados en caliente
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CTC 52. Equipamiento para carreteras
CTC 61. Hormigón preparado
CTN 036. Siderurgia
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CTN 199. Equipamiento para la gestión de tráfico

Asociación Española de Riegos y Drenajes (AERYD)

Asociación Española de Teledetección (AET)

Asociación Internacional de Geología Aplicada a la Ingeniería (AEGAIN)
Comisión nº 10 Rocas para Edificios y Ornamentales

Asociación Internacional de Geología Aplicada a la Ingeniería (AEGAIN)
Comisión nº 10. Rocas para edificios y ornamentales

Asociación Mundial de la Carretera (AIPCR/PIARC)
Comisión de terminología y traducción asistida (CTERM)
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TS C.2 Explotación vial más segura
TS D.3 Puentes de carretera
TS D.4 Geotecnia y carreteras sin pavimentar

Asociación Técnica de Carreteras (ATC). Comité Nacional Español de la AIPCR
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C05. Túneles de carreteras
C07. Características superficiales de los pavimentos
C08. Firmes de carreteras
C11. Puentes de carreteras
C12. Geotecnia vial
C13. Seguridad vial
C14. Carreteras y medio ambiente
CT21. Geotextiles

Asociación Técnica de Puertos y Costas
Comité Técnico de Gestión Ambiental (COTEMA)

Association for European Transport (AET)
PC Applied Methods in Transport Planning
PC Planning for Sustainable Land Use and Transport

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CINDOC. Comité de evaluación

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CE. Proyecto PL/06/IB/EN/02 *Communication, Public Awareness and Capacity Building for the EU Natura 2000 Ecological Network.*
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Comisión Permanente de Normas Sismorresistentes

Comisión Permanente del Cemento

Comisión Permanente del Hormigón

Comisión Técnica de redacción del documento *Indicadores de fragmentación del hábitat*
GT Fragmentación de Hábitats causada por Infraestructuras de Transporte
Comité de expertos encargado del Desarrollo de la Instrucción Técnica sobre Caudales Ecológicos

Comité de expertos para la aplicación del Artículo 37 del [Tratado] Euratom

Comité Estatal de Coordinación del Plan Estatal de Protección Civil ante el Riesgo Sísmico (CECO)

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Conférence européenne des directeurs de routes

Convenio de Bonn
Grupo de trabajo OSINET (*oil spill identification network*)

Convenio Oslo-París para la Protección del Atlántico Nordeste
Comité de Eutrofización (EUC)
Grupo de Trabajo sobre Impacto Ambiental por Actividades Humanas (EIHA)

Directiva Marco del Agua. Estrategia común de implantación.
Grupo general de intercalibración en aguas costeras y de transición (COAST)
Grupo geográfico de intercalibración de la eco-región mediterránea (COAST MED-GIG)
Grupo A. Estado ecológico (WGA ECOSTAT)
Grupo F. Inundaciones
Grupo. Intercalibración

Documentación Internacional de Investigación en Transporte (ITRD/DIIT)
Centro Coordinador para el idioma español
Comité Operacional del Programa ITRD/DIIT
Sub-Comité de Terminología del Programa ITRD/DIIT
ITRD Review Group: grupo de Trabajo para la revisión del funcionamiento de la base de datos ITRD/DIIT

Escuela de Organización Industrial (EOI). Consejo Asesor de los Programas de Medio Ambiente y Calidad

European Committee for Standardization (CEN)
TC 051. Cementos y cales de construcción
TC 154. *Aggregates*
TC 189. Geotextiles y productos relacionados
TC 226. Dotaciones viales
TC 227 Materiales para carreteras
TC 250. Eurocódigos estructurales
CEN JWC 139/254. Geomembranas
Comité Europeo para la Definición de Indicadores Hidromorfológicos en el Ámbito de la Directiva Marco del Agua

European Conference of Transport Research Institutes (ECTRI). General Assembly
TWG Traffic safety and security
TWG Transport economy
TWG Urban transport

European Large Geotechnical Institutes Platform (ELGIP)

EMS (European Microscopy Society). Comité

European Platform on Mobility Management (EPOMM)

European Water Research Institutes (EWRI)
Directors Meeting

Federación Española de Asociaciones de Archiveros, Bibliotecarios, Arqueólogos, Museólogos y Documentalistas (ANABAD)

Federation of International Geotechnical Societies (FIGS). Joint Technical Committee 3

Forum of European National Highway Research Laboratories (FEHRL). Comité Ejecutivo. General Assembly.

Fundación J. García-Siñeriz
Jurado de los premios anuales de geofísica

Grupo de Trabajo Nacional sobre Inundaciones (GTNI)

I Encuentro del Centro Ibérico de Restauración Fluvial (CIREF). Comité Organizador

Institute of Electrical and Electronics Engineers (IEEE)

Institution of Railway Signal Engineers (IRSE)

Integración Fluvial de Sudamérica (IFSA)

International Association for Bridge and Structural Engineering (IABSE)

International Association for Shell and Spatial Structures (IASS)

International Association of Hydraulic Engineering and Research (IAHR). Secretaría
Sección de Instrumentación
Hydraulic Structures Committee
IAHR/IWA Committee on Marine Outfall Systems

International Atomic Energy gency. Proyecto Coordinado de Investigación *Geostatistical analysis of spatial isotope variability to map the sources of water for hydrology and climate studies.*

International Commission on Irrigation and Drainage (ICID). WG on Irrigated Agriculture under Drought and Water Scarcity

International Commission on Large Dams (ICOLD)

International Desalination Association (IDA)

International Federation for Structural Concrete (FIB)

International Geosynthetics Society (IGS)
Capítulo Español

International Society for Soil Mechanics and Geotechnical Engineering
TC 03. Geotecnia de carreteras
TC 16. Ensayos in situ
TC 20. Práctica profesional en Geotecnia
TC 29. Ensayos de laboratorio
ETC 10. Análisis del Eurocódigo 7
ETC 12. Análisis del Eurocódigo 8

International Society of Limnology (SIL)

International Transport Forum (ITF). Centro Conjunto de Investigación del Transporte
Joint Transport Research Committee (JTRC)

International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM). Comité de Gestión
TC *Progress of Recycling in the built environment*

International Water Supply Association (IWSA)
Joint OECD/ITF Transport Research Centre

Jornadas Española de Ingeniería de Costas y Puertos. Comité Técnico Permanente

Ministero dell´Istruzione, dell'Università e della Ricerca (MIUR).
Evaluador "Ingeniería Civil y Medioambiental"

OCDE Nuclear Energy Agency. NEA Data Bank

Organización Marítima Internacional (OMI)
Comité de Protección del Medio Marino (MEPC)
Reunión Consultiva de las Partes Contratantes del Convenio de Londres y del Protocolo de Londres

PIANC. Sección Española. Comité Técnico nº 2

Plataforma Tecnológica de Laboratorios de Hidráulica de España (PTLHE)

Plataforma Tecnológica Española de la Construcción

Plataforma Tecnológica Española del Agua y el Riego (PTEAR). GT 9. Sostenibilidad

Programa Alemán de Investigación de Transportes (Fundación Helmholz, Ministerio de Transporte Alemán. Evaluador

Programa Hidrológico Internacional (UNESCO)
Comité Nacional Español

Programa Nacional de Acciones Complementarias

Programa ROM (Recomendaciones de Obras Marítimas). Comité Técnico Permanente y Comisión General

Red de Institutos Nacionales Iberoamericanos de Ingeniería e Investigación Hidráulica

Red Iberoamericana Agua y Ciudad

Red Iberoamericana para el Monitoreo y Pronóstico de Fenómenos Hidrometeorológicos

Red Tecnológica PREVECMA

Red Temática Estudios sobre cianotoxinas y su incidencia en España

Servicio de Teledocumentación Baratz
Grupo de Usuarios de BRS

Sistema Nacional de Cartografía de Zonas Inundables (SNCZI). Grupo de trabajo de inundaciones y comisión técnica.

Sociedad Española de Acústica

Sociedad Española de Cromatografía y Técnicas Afines (SECYTA). Sociedad Española de Documentación e Información Científica (SEDIC)

Sociedad Española de Ficología (SEF)

Sociedad Española de Mecánica de Rocas (SEMR)

Sociedad Española de Mecánica del Suelo e Ingeniería Geotécnica (SEMSIG)

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Sociedad Geológica de España (SGE)

Sociedad Nuclear Española (SNE)

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Système Euro-Méditerranéen d'Information sur les savoir-faire dans le Domaine de l'Eau /Euro-Mediterranean Information System on know-how in the Water sector (SEMIDE/EMWIS)
Comité de Dirección. Unidad Técnica

Transportation Research Board (TRB)
Comité AFD40 - Full scale and accelerated paving testing

Universidad de Missouri. Comité de Premios Prakash

Universidad Politécnica de Madrid. ETS de Arquitectura. Comité de restauración, conservación y del patrimonio arquitectónico

VI Congreso de la Asociación Española de Ingeniería del Paisaje
Comité Científico

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Comisión Asesora de Publicaciones del Ministerio de Fomento

ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
3D	Tridimensional
ACIES	Asociación de Consultores Independientes de Estructuras de Edificación
ADIF	Administrador de Infraestructuras Ferroviarias
AEAS	Asociación Española de Abastecimientos de Agua y Saneamiento
AECID	Agencia Española de Cooperación Internacional para el Desarrollo
AEMA	Agencia Europea de Medio Ambiente
AEMET	Agencia Estatal de Meteorología
AENOR	Asociación Española de Normalización y Certificación
AETESS	Asociación de Empresas de Técnicas Especiales del Suelo y del Subsuelo
AETOS	Asociación Española de Túneles y Obras Subterráneas
AIPCR/PIARC	Asociación Mundial de la Carretera
AMECO	Annual Macroeconomic Database
ANCADE	Asociación Nacional de Fabricantes de Cales y Derivados de España
ARQUA	Museo Nacional de Arqueología Subacuática
ASLO	American Society of Limnology and Oceanography
ASSET	Proyecto de investigación: Assessing Sensitiveness to Transport
ASTM	American Society for Testing and Materials
ATEBA	Asociación técnica española de balsas y pequeñas presas
AVE	Alta Velocidad Española
BAM	Bundesanstalt für Materialforschung und -prüfung
BIT	Aplicación datos sobre incidentes en túneles
BTM	Balise Transmission Module
CARS	China Academy of Railway Sciences
CATA	Catálogo de la red de bibliotecas del CEDEX
CBR	California Bearing Ratio
CE	Comisión Europea
CEDR	Conférence Européenne des Directeurs de Routes
CEHOPU	Centro de Estudios Históricos de Obras Públicas y Urbanismo
CENIT	Consorcios Estratégicos Nacionales de investigación: Tecnológica
CENTA	Fundación Centro de las Nuevas Tecnologías del Agua
CH	Confederación Hidrográfica
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
CIMNE	Centro Internacional de Métodos Numéricos en Ingeniería
CIUDEN	Fundación Ciudad de la Energía
CLEAM	Proyecto de investigación: Construcción Limpia, Eficiente y Amigable con el Medio Ambiente
CLOSER	Proyecto de investigación: Connecting long and short distance networks for efficient transport
CORINE	Coordination of Information of the Environment
CSN	Consejo de Seguridad Nuclear
CTERM	Comité de Terminología y Ayuda a la Traducción
DEA	Diploma de Estudios Avanzados
DG	Dirección General
DGA	Dirección General del Agua
DGC	Dirección General de Carreteras
DGCEA	Dirección General de Calidad y Evaluación Ambiental
DGHyCA	Dirección General de Obras Hidráulicas y Calidad de las Aguas
DGIF	Dirección General de Infraestructuras Ferroviarias
DGLAB	Dirección General del Libro, Archivos y Bibliotecas
DGMM	Dirección General de la Marina Mercante
DGP	Dirección General de Planificación
DGSCM	Dirección General de Sostenibilidad de la Costa y del Mar
DGT	Dirección General de Tráfico
DIIT	Documentación Internacional de investigación: en Transporte. Ver ITRD
DIRCAIBEA	Consejo de Directores de Carreteras de Iberia e Iberoamérica
DIRECT-MAT	Dismantling and Recycling Techniques for Road Materials

ABBREVIATIONS	DESCRIPTION
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DOI	Digital Object Identifier
ECTRI	European Conference of Transport Research Institutes
EDAR	Estación Depuradora de Aguas Residuales
EEA	European Environment Agency
EGRA	Evaluación y Gestión del Ruido Ambiental
EGU	European Geosciences Union
ELGIP	European Large Geo-Engineering Institutes Platform
ELLPAG	European Long-Life Pavement Group
EN	European Norm
ENAC	Entidad Nacional de Acreditación
EOI	Escuela de Organización Industrial
EOLIA	Proyecto de investigación:
EPOMM	European Platform on Mobility Management
EPOMM-PLUS	European Platform on Mobility Management-Partners Learning Urban Sustainability
ERA-NET Road	European Research Area-Networking Road
ERTMS	European Railway Traffic Management System
ERTRAC	European Road Transport Research Advisory Council
ETCS	European Train Control System
ETS	Escuela Técnica Superior
EUROSTAT	Oficina Estadística de la Unión Europea
FAO	Organización de las Naciones Unidas para la Agricultura y la Alimentación
FEHRL	Forum of European Highway Research Laboratories
FENIX	Proyecto de investigación: en Carreteras más Seguras y Sostenibles
FFFIS	Form Fit Functional Interface Specification
FFIA	Fundación para el Fomento de la Ingeniería del Agua
FiWi	FEHRL institutes WIM initiative
FTIR	Fourier Transform Infrared (Spectrosopy)
GC	Gas Chromatography
GEOPLAT	Plataforma Tecnológica Española de Geotermia
GNIP	Global Network of Isotopes in Precipitation
GNSS	Global Navigation Satellite Systems
GPR	Ground Penetration Radar
GRAIL	Proyecto de investigación: GNSS Introduction in the Rail Sector
HIDRO	Base de datos sobre el agua
IAHR	International Association of Hydro-Environment Engineering and Research
IbSTT	Asociación Ibérica de Tecnología sin Zanja
ICOG	Ilustre Colegio Oficial de Geólogos
ICOGA	Ilustre Colegio Oficial de Geólogos de Andalucía
IEC	International Electrotechnical Commission
IECA	Instituto Español del Cemento y sus Aplicaciones
IGAE	Intervención General de la Administración del Estado
IGME	Instituto Geológico y Minero de España
INE	Instituto Nacional de Estadística
INNOTRACK	Proyecto de investigación: Innovative Track Systems
INNOVA-MED	Proyecto de investigación: Procesos y prácticas innovadores en el tratamiento y reutilización de aguas residuales en la región mediterránea
INTEVIA	Instituto Técnico de la Vialidad y del Transporte
IRI	International Roughness Index
ISO	International Organization for Standardization
ITIL	Information Technology Infrastructure Library
ITRD	OCDE International Transport Research Documentation (transport research database)
LAV	Línea de alta velocidad
LEU	Lineside Equipment Unit
LiDAR	Light Detection And Ranging
LINK	European Forum on Intermodal Passenger Travel
LVDT	Linear Variable Differential Transformer
MARM	Ministerio de Medio Ambiente y Medio Rural y Marino
MARQ	Museo Arqueológico de Alicante
MAS	Masa de agua subterránea
MS	Mass Spectrometry

ABREVIACIÓN	LITERAL
NFU	Neumáticos Fuera de Uso
NONESCON	Proyecto de investigación: Utilización de resi duos de construcción y demolición en hormi gón no estructural
OASIS	Proyecto de investigación: Operación de Autopistas Seguras y Sostenibles
OCDE	Organización para la Cooperación y el Desarrollo Económico
OIEA	Organismo Internacional de la Energía Atómica
OMI	Organización Marítima Internacional
OMM	Organización Meteorológica Mundial
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAR	Plan de Acción contra el Ruido
PEIT	Plan Estratégico de Infraestructuras y Transporte
PREVECMA	Prevención y respuesta a los vertidos marinos
PSD	Position Sensitive Detector
PTLHE	Plataforma Tecnológica de Laboratorios de Hidráulica de España
RBC	Radio Block Centre
RCD	Residuos de Construcción y Demolición
RCE	Red de Carreteras del Estado
REVIP	Red Española de Vigilancia de Isótopos en la Precipitación
RINA	Registro Italiano Navale
RLHE	Red de Laboratorios de Hidráulica de España
ROEA	Red Oficial de Estaciones de Aforo
ROM	Recomendaciones de obras marítimas
RVRA	Red de Vigilancia Radiológica Ambiental
SAIH	Sistema Automático de Información Hidrológica
SASEMAR	Sociedad de Salvamento y Seguridad Marítima
SCRIM®	Sideway-force Coefficient Routine Investigation Machine
SECEGSA	Sociedad Española de Estudios para la Comunicación Fija a Través del Estrecho de Gibraltar, S.A.
SECYTA	Sociedad Española de Cromatografía y Técnicas Afines
SEMIDE/EMWIS	Système euro-méditerranéen d'information sur les savoir-faire dans le domai ne de l'eau/Euro-Mediterranean Information System on know-how in the Water sector
SEMR	Sociedad Española de Mecánica de Rocas
SEPREM	Sociedad Española de Presas y Embalses
SIAGUA	Sistema Iberoamericano de Información sobre el Agua
SIG	Sistema de Información Geográfica
SIGAP	Sistema Integral de Gestión para la Auscultación de Presas
SIMEPROVI	Asociación Española de Fabricantes de Sistemas Metálicos de Protección Vial
SIMPA	Sistema Integrado para la Modelación del proce so Precipitación Aportación
SISTIA	Sistema de Indicadores del Sector del Transporte y su Impacto Ambiental
SNCZI	Sistema Nacional de Cartografía de Zonas Inundables
SNED	Société Nationale d'Études du Detroit de Gibraltar
SPH	Smoothed Particle Hydrodynamics (Hidrodinámica de partículas suavizada)
SRS	System Requirements Specifications
SUPERTRACK	Proyecto de investigación: Sustained Performance of Railway Tracks
TRB	Transportation Research Board
TSD	Test Sequences Debugger
UCM	Universidad Complutense de Madrid
UE	Unión Europea
UIC	Union Internationale des Chemins de fer
UNE	Una Norma Española
UNISIG	Union Industry of Signaling
UPC	Universitat Politècnica de Catalunya
UPM	Universidad Politécnica de Madrid
UTE	Unión Temporal de Empresas
WIM	Weigh-in-motion
WoK	Web of Knowledge
XPRES	Proyecto de investigación:
YELGIP	Youth European Large Geo-Engineering Institutes Platform