



International Conference

Durable Structures

From construction to rehabilitation

31st May - 1st June 2012 • Lisbon • Portugal

programme



LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL



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Foreword

It is both my honor and pleasure to welcome you to the International Conference ICDS12–DURABLE STRUCTURES- from construction to rehabilitation, taking place on 31st May and 1st June 2012 at Laboratório Nacional de Engenharia Civil (National Laboratory for Civil Engineering), in Lisbon, Portugal. This International Conference is a co-organization of LNEC and the network DURATINET. Since the 90's, LNEC has organized and hosted several national and international meetings in the field of the durability of structures.

The main topics proposed for this Conference are: construction materials (steel and concrete,...), deterioration processes and modelling, environmental loads and service life prediction, testing and diagnostic techniques, concrete treatments and repair methods, steel protection methods, innovative repair and protection systems, sustainable construction materials (using waste and recycled materials), monitoring of structures, reliable asset management and structural safety, and case studies.

Around 90 papers have been accepted for oral presentations covering all several topics. Six keynote lectures in relevant subjects on structures durability will be also presented. The technical sessions for oral presentations were organized according to six main themes: durability; assessment and inspection; management, maintenance and monitoring; repair; sustainability; and case studies.

With the aim of complementing the technical programme of ICDS12, the specialization Course “Testing techniques for structures inspection” and the Final Transnational Workshop of the project DURATINET were also organized in the previous two days.

In the behalf of the Organizing Committee of this Conference I would like to acknowledge the Advisory Committee for the pertinent suggestions and advice, and to the Scientific Committee Members for the revision of all extended abstracts. Our thanks are also extended to the Keynote Speakers and to the Authors of Papers submitted for their contribution to the success of ICDS12. I hope that this Conference is a success, not only from the scientific point of view, but also provides a pleasant stay in Lisbon to all participants.

I also want to express our gratitude to the Board of Directors of LNEC, I.P., for supporting this International Conference and for the facilities made available to the organization of this event. Thanks are also due to all participating institutions and sponsors of this event.

Lastly, I would like to particularly acknowledge the colleagues of the Organizing Committee and all members of LNEC staff who actively co-operated in the organization of this event

M. Manuela Salta

Chairwoman of ICDS12 Organizing committee

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General programme

May 29th

9-00	13-00	Course on "Testing techniques for structures inspection"
13-00	14-00	Lunch
14-00	18-00	Course on "Testing techniques for structures inspection"

May 30th

9-00	13-00	Course on "Testing techniques for structures inspection"	
14-00	17-00	ICDS12 Registration	7 th Trans-National DURATINET Workshop
17-00		Welcoming reception	

May 31st

		ROOM 1	ROOM 2
9-00	9-30	Opening Session	
9-30	10-00	Keynote 1	
10-00	11-00	CASE STUDY F1	DURABILITY A1
11-00	11-15	Coffee break	
11-15	11-45	Keynote 2	
11-45	13-15	ASSESSMENT & INSPECTION B1	REPAIR C1
13-15	14-15	Lunch	
14-15	14-45	Keynote 3	
14-45	16:15	MAINTENANCE & MONITORING D1	REPAIR C2
16-15	16-30	Coffee break	
16-30	17-00	Keynote 4	
17-00	18-30	DURABILITY A2	ASSESSMENT & INSPECTION B2
20-00		Conference Dinner	

June 1st

9-00	10-45	CASE STUDY F2	
10-45	11-00	Coffee break	
11-00	11-30	Keynote 5	
11-30	13-00	DURABILITY A3	DURABILITY A4
13-00	14-15	Lunch	
14-15	14-45	Keynote 6	
14-45	15-45	MAINTENANCE & MONITORING D2	Technical Demonstration Session
15-45	16-00	Coffee break	
16-00	16-30	Keynote 7	
16-30	18-00	SUSTAINABILITY E	
18-00	18-30	Awards & Closing Session	

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Keynotes

Keynotes

May 31 th			
1	9:30-10:00	Júlio Appleton	Design for durability of concrete structures
2	11:15-11:45	Franck Schoefs	Degradation models and measurement of corrosion in marine environment: state of the art and challenges
3	14:15-14:45	Manuela Salta	Durable structures. What we need to learn more!
4	16:30-17:00	Carmen Andrade	Limit state calculation of reinforcement corrosion
June 1 st			
5	11:00-11:30	Karim Ait-Mokhtar	Mechanisms involved in chloride transport through reinforced concrete – simulations of their effects on corrosion initiation
6	14:15-14:45	Muhammed Basheer	Novel sensors for monitoring the durability of concrete structures
7	16:00-16:30	Arlindo Gonçalves	Sustainability of construction materials. An overview

Keynote 1

Design for durability of concrete structures

J. Appleton

A synthesis of basic durability concepts will be presented as an introduction (main deterioration mechanisms, initiation and propagation phases, microenvironments, design service life). Durability design models at macro level and meso level will be presented and illustrated with examples.

The durability design strategies and specifications for 3 new structures will be presented. Finally the experience collected from 17 major repair works will be evaluated (age of repairs, main cause of deterioration) to conclude with some recommendations to improve the durability of concrete structures.

Keynote 2

Degradation models and measurement of corrosion in marine environment: state of the art and challenges

F. Schoefs

This paper summarises research led during the second phase of the French GEROM (Risk management of maritime and river harbour structures) project and Medachs project. A stochastic (spatial-temporal) model of steel corrosion is proposed. Error of measurements are measured and modelled. It is shown how to optimize the number of measurements. A review of models is presented too.

Keynote 3

Durable structures. What we need to learn more?

Manuela Salta

Steel and reinforced concrete structures can be durable structures if they are adequately designed, constructed and maintained. However, in practice, experience has shown that performance failures associated to deterioration often occur in structures only few years after their construction, requiring unscheduled maintenance actions and in many cases involving expensive repair works.

In this presentation, a short review on the evolution of these two structural materials characteristics and properties, from the beginning of their application in civil engineering structures and respective implications on structural performance is done.

Based on the experience gained in case studies of real structures regarding performance loss and materials failure, considerations are made about these two most common structural materials performance, strengths and weaknesses, which from the author's viewpoint, should be considered as key factors, hence, deserving particular attention on construction of new structures and repairing of existent ones to obtain more durable and sustainable structures for the benefit of the future generations.

Keynote 4

Limit state calculation of reinforcement corrosion

C. Andrade, F. Tavares and D. Izquierdo

In present paper are analysed the key aspects to be specified in service life models in which not only to the test methods to determine the diffusion coefficient should be defined, but also the chloride surface concentration and the so called "aging factor". The same should apply to the chloride threshold value which is addressed in the paper by comparing the statistical distribution found in mortar specimens in the laboratory and that found in real structures.

Keynote 5

Mechanisms involved in chloride transport through reinforced concrete – simulations of their effects on corrosion initiation

O. Amiri and A. Aït-Mokhtar

The keynote aims an overview of the different phenomena induced by chloride transport through cement-based materials. Since chloride transport is ionic transport within a reactive porous medium, this process involves ionic interactions between ions, chemical reaction between chloride and the solid phase, mainly cement paste and electrochemical interactions between ionic species in pore solution and pore interface. In a second step, effects of these phenomena on the evolution of chloride concentrations at the vicinity of the reinforcement are studied in both cases: saturated transport, which involves only diffusion process and unsaturated transport in case of wetting-drying cycles, where hydric convection can be predominant.

Keynote 6

Novel sensors for monitoring the durability of concrete structures

P. A. Muhammed Basheer, S. Srinivasan, S. Nanukuttan, W. J. McCarter, M. Chrisp, T. Sun and K. T. V. Grattan

Monitoring of structures is important for understanding their response to both structural and environmental loadings in their service. The development of integrated monitoring systems for new and existing structures could reduce costs by allowing a more rational approach to the assessment of repair options and scheduling of inspection and maintenance programmes. Electrical and optical fibre sensor systems have emerged during the past ten years to satisfy these requirements. This paper describes some of these sensor systems and highlights the range of monitoring applications which can be addressed so as to reduce the life cycle cost of structures. Some of the most recent data are also reported.

Keynote 7

SUSTAINABILITY OF CONSTRUCTION MATERIALS: AN OVERVIEW

A. Gonçalves and I. M. Martins

After the Brundtland Commission sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”

Initially sustainability was mainly addressed from an environmental perspective, but later the importance of social and economical issues was recognized and so they were integrated in the sustainability concept.

Within the construction sector guidance documents and standards were developed establishing the basis for sustainability of materials and buildings. In this paper a review of documents on sustainability of construction works is presented along with some examples of developed applications, pointing out the difficulties on getting quality data and weighing indicators to support decision-making.

Theme A

Durability

SESSION A1

May 31 th	Chairpersons: Ramón Nóvoa and António Baptista	
10:00-10:15	<u>M. J. Correia</u> and M. M. Salta	Stainless steel rebar for long service life
10:15-10:30	<u>J.A.F.O. Correia</u> , A.M.P. Jesus and A. Fernández-Canteli	Probabilistic fatigue behaviour of a structural detail of puddle iron from the Eiffel bridge
10:30-10:45	<u>Hugo Perna</u> , Maria João Correia and Manuela Salta	Corrosion protection of steel structures
10:45-11:00	<u>M. J. F. Marques</u> , I. N. Alves, R. P. Gonçalves and T. C. Diamantino	Assessment of corrosion in offshore environment. Study in windfloat prototype: Wind_enermar project

Stainless steel rebar for long service life

M. J. Correia and M. M. Salta

This communication addresses current specifications and recommended practices for the use of stainless steel reinforcing bars in concrete structures. It also includes related important research findings and experience with successful applications.

Probabilistic fatigue behaviour of a structural detail of puddle iron from the Eiffel bridge

J.A.F.O. Correia, A.M.P. Jesus and A. Fernández-Canteli

In this paper, a probabilistic approach is proposed to generate S-N curves for stress ratio $R=0$, applied to a structural detail of puddle iron from the Eiffel Bridge supported on the UniGrow model, which is applied to predict both crack initiation and crack propagation in a unified fatigue approach.

Corrosion protection of steel structures

Hugo Perneta, Maria João Correia and Manuela Salta

Corrosion is the main deterioration mechanism of metallic materials. Therefore, corrosion prevention by protection of metallic structures is essential for structures safety, integrity, and function and, thus, for long service life.

This paper presents the most commonly used corrosion protection systems identifying the most important factors for an effective protection of steel structures.

Assessment of corrosion in offshore environment. Study in windfloat prototype: Wind_enermar project

M. J. F. Marques, I. N. Alves, R. P. Gonçalves and T. C. Diamantino

In December 2011 WindFloat prototype, a semi-submersible floating structure was successfully deployed off the coast of Aguçadoura, North Sea of Portugal. The 2 MW WindFloat platform is the first offshore wind turbine in open Atlantic waters and as a demonstration project it appears as great opportunity to assess metal corrosion and anticorrosive protection systems efficiency in offshore environment. This kind of assessment has never been performed in Portugal. With this aim, the Materials and Coatings Laboratory (LMR) of LNEG carried out the Wind_Enermar project - "Prevention and control of corrosion in the exploitation of offshore wind energy", which involved the exposure of AH36 steel samples with and without application of different anticorrosive protection systems, selected according to the different sections of the WindFloat platform: atmospheric, splash and immersion zone.

SESSION A2

May 31 th	Chairpersons: Carmen Andrade and Paula Rodrigues	
17:00-17:15	<u>S. Nanukuttan</u> , M. Basheer and C. Lagan	Effect of climate change on concrete carbonation
17:15-17:30	<u>J. Mai-Nhy</u> , A. Sellier, P. Rougeau, F. Duprat and M. Salta	Numerical tool for durability assessment of concrete structures subjected to aggressive environment
17:30-17:45	<u>Rui Neves</u> , Fernando Branco and Jorge de Brito	A simple durability design method for carbonation-induced corrosion
17:45-18:00	<u>C. Green</u> , S. Nanukuttan and M. Basheer	Role of performance indicators in assessing the state-of-health of concrete infrastructure
18:00-18:15	<u>M.T. Pinheiro-Alves</u>	Limitations of durability of portland cement-based concretes due to sulphate attack
18:15-18:30	<u>A.Velosa</u> , C. Figueiredo, P. Cachim and O. Cascudo	Metakaolin influence in chloride penetration in concrete

Effect of climate change on concrete carbonation

S. Nanukuttan, M. Basheer and C. Lagan

This paper outlines the impact of climate change on the carbonation of concrete. The intention is to quantify the effect of climatic change on variables, such as temperature, atmospheric carbon dioxide concentration and relative humidity, on carbonation of concrete so that the need to modify current durability specifications given in EN206-1 can be highlighted. The information presented and discussed in this paper is useful for: (1) developing climate change mitigation strategies for existing structures; and (2) specifying new concrete structures in XC1 to XC4 exposure environments by taking account of the impact of the climate change.

Numerical tool for durability assessment of concrete structures subjected to aggressive environment

J. Mai-Nhu, A. Sellier, P. Rougeau, F. Duprat and M. Salta

Mastering and optimising the durability of prefabricated products, whether they are structural, architectural or intended for sewerage, is without a doubt a major challenge for the entire profession. Previous works carried out at CERIB and LMDC have already resulted in the creation of a predictive model for assessing the lifetime of reinforced concrete structures subjected to the phenomenon of carbonation.

In this research work, additional parameters of corrosion are being introduced such as the migration of chlorides in a saturated and unsaturated phase or the combination of this migration with the mechanism of carbonation and the corrosion of reinforcing bars according to wetting-drying cycles.

A simple durability design method for carbonation-induced corrosion

Rui Neves, Fernando Branco and Jorge de Brito

This work aims at providing a simple semi-probabilistic approach to service life design of reinforced concrete structures, in what concerns reinforcement corrosion induced by concrete carbonation.

An analytical model for the initiation period, using as input parameters the accelerated carbonation resistance and the environmental class, is presented. A maximum accepted level of deterioration and reliability indexes are defined. The corresponding partial safety factors are derived from a full probabilistic approach. The performance of the proposed method is compared with that of a reference method (LNEC E 465).

Role of performance indicators in assessing the state-of-health of concrete infrastructure

C. Green, S. Nanukuttan and M. Basheer

In order to construct structures which will perform satisfactorily in chloride exposure environments, the following two aspects need to be developed: a performance based specification to supplement EN 206-1 which will outline the expected performance of the structure in a given environment; and a simple yet industry-adaptable procedure for assessing the performance of structures in service. This paper aims to recognise the factors/variables which have a significant influence on the chloride ingress into concrete. These factors/variables are termed as performance indicators (PIs) and are evaluated in this paper through the use of several case studies.

Limitations of durability of portland cement-based concretes due to sulphate attack

M.T. Pinheiro-Alves

Presently, the existence of a cement that by itself is capable of resisting sulfates is questioned by several authors. The current standards, also do not consider all forms of sulphate attacks. The prevention of ettringite and thaumasite cannot be treated the same way, because they require multiple sources of ions for forming. With a new accelerated method the Portland cement CEM I was tested. This method included an attack with sodium sulfate and magnesium sulphate. Results obtained indicated that samples immersed in sodium sulphate performed better than the ones exposed to magnesium sulphate.

Metakaolin influence in chloride penetration in concrete

A.Velosa, C. Figueiredo, P. Cachim and O. Cascudo

Chloride ingress in reinforced concrete is especially deleterious, causing the corrosion of steel and the consequent cracking of the surrounding concrete. Metakaolin, due to its high aluminate content may react with chlorides forming Friedel's salt, delaying chloride ingress and promoting durability.

SESSION A3

June 1 st	Chairpersons: Karim Ait-Mokhtar and Maria Sofia Ribeiro	
9:30-9:45	<u>Jean Herisson</u> , Marielle Guéguen, Eric D. van Hullebusch, Pascal Tacquet and Thierry Chaussadent	Reaching more sustainable materials for sewer networks through an accelerated test
9:45-10:00	<u>João P. Sousa</u> , Susana Cabral-Fonseca and João R. Correia	Environmental degradation of GFRP pultruded profiles made of polyester and vinylester resins
10:00-10:15	<u>Ola Skjølsvold</u> and Eva Rodum	Application of water vapour tight coatings on early age (green) concrete
10:15-10:30	David James Wilson	Controlled permeability formwork liners in constructing wastewater treatment plants
10:30-10:45	<u>A. Soufi</u> , P-Y. Mahieux, A. Ait-Mokhtar and O. Amiri	Durability performance based approach of mortars patch repair
10:45-11:00	Eduardo Teixeira	Behavior of anchor systems in cracked concrete under tension loading

Reaching more sustainable materials for sewer networks through an accelerated test

Jean Herisson, Marielle Guéguen, Eric D. van Hullebusch, Pascal Tacquet and Thierry Chaussadent

Sewer networks are subject to biodeterioration, a damaging process based on the production of sulfuric acid by microorganisms in specific conditions. Aerial part of this phenomenon can be split in four stages. The study of the mechanisms both on site and in lab brings information for the design of an accelerated test.

This study highlights the absolute need of H₂S and of a succession of microorganisms in an effective and standardisable accelerated biodeterioration test. This test, developed by Ifsttar, brings interesting results. In near future, it will be a way to rank materials according to their ability to resist to biodeterioration, and to select only the more durable ones.

Environmental degradation of GFRP pultruded profiles made of polyester and vinylester resins

João P. Sousa, Susana Cabral-Fonseca and João R. Correia

This paper presents results of an on-going study about the durability of glass fibre reinforced polymer (GFRP) pultruded profiles made of E-glass fibres and vinylester and polyester resins when exposed to environmental degradation agents. Small-scale coupons of GFRP profiles were exposed to natural ageing in an urban environment during 3 years and to artificial accelerated ageing in a QUV chamber up to 3000 hours. The effects of such exposure conditions were assessed regarding the changes on physical, chemical, aesthetical and mechanical properties of the material.

Application of water vapour tight coatings on early age (green) concrete

Ola Skjølsvold and Eva Rodum

This paper presents the results from a test programme performed in order to verify the bond properties of water vapour tight membranes applied on early age (green) concrete. Two suppliers participated in the test programme. The membranes were applied directly after demolding, 1 day after casting, as well as 7 days later. Two different temperature regimes were established after application of the membranes. The temperature condition was controlled by heating cables, and the variable involved was the temperature gradient from the centre of the cube to the surface. The verification of bond properties was performed as tensile bond strength testing by direct dolly pull-off.

Controlled permeability formwork liners in constructing wastewater treatment plants

David James Wilson

Density and strength of the concrete is of paramount importance in ensuring the quality of the outer concrete surface. Penetration of toxic liquids or gaseous substances should be completely excluded wherever possible. Otherwise the depth of penetration of such harmful agents should be kept to a minimum to minimize chemical attack to the cover zone in general and the surface in particular.

Significant laboratory based research projects have been executed into the improved performance of concrete cast using a CPF liner. In-service evidence is not as readily available due to the required time frames. This paper shows that CPF use is of real benefit in increasing the service life of structures even after a period of only 10 years.

Durability performance based approach of mortars patch repair

A. Soufi, P-Y. Mahieux, A. Aït-Mokhtar and O. Amiri

This study deals with the performance-based approach on the durability of mortar patch repairs (MPR), with respect to chloride-induced reinforcement corrosion in marine environmental conditions. To assess the durability of mortars repair system, the research was based on the comparison of the main durability indicators (porosity, permeability, capillary absorption, effective chloride diffusion coefficient) of six repair industrial materials and one reference concrete. We have highlighted that the physical and transfer properties of the materials studied are effective to reduce the kinetic chloride penetration and to improve the reinforcement corrosion resistance.

Behavior of anchor systems in cracked concrete under tension loading

Eduardo Teixeira

For a safe design of post-installed anchorages the first step is the correct definition of the base material and the acting loads. The interaction between the load and the base material is carried out through load transfer mechanisms which can be typically identified as mechanical interlock, friction or bond.

The behaviour of these different mechanisms has to be well-thought-out particularly when the installation is made in reinforcement or rehabilitation projects where the base material can frequently be cracked concrete.

SESSION A4

June 1 st	Chairpersons: Jorge de Brito and Géraldine Villain	
9:30-9:45	<u>Mahfoud Tahlaiti</u> , Stéphanie Bonnet and Pierre Mounanga	Hydration rate and compressive strength of metakaolin-cement blended mortars cured at different temperatures
9:45-10:00	B. Díaz, <u>X.R. Nóvoa</u> , B. Puga and V. Vivier	Chloride transport through cementitious membranes using pulsed current
10:00-10:15	<u>José Santos</u> and A. Abel Henriques	Ductility of damaged reinforced concrete beams
10:15-10:30	<u>A. Belarouci</u> , F. Ghomari, A. Khelidj and A. Bezzar	Concrete building in marine environment – prevention of chloride induced reinforcement corrosion
10:30-10:45	<u>A. Soufi</u> , P-Y. Mahieux, A. Aït-Mokhtar and O. Amiri	Effect of microclimate on the durability of concrete structures
10:45-11:00	<u>W. V. Beiral</u> , S.G. Gonzales and D.P. Dias	Theoretical and experimental study of the shear beams reinforced with bars fiber glass

Hydration rate and compressive strength of metakaolin-cement blended mortars cured at different temperatures

Mahfoud Tahlaoui, Stéphanie Bonnet and Pierre Mounanga

This study aims to investigate the effects of curing temperature (10, 15, 20, 40°C) on metakaolin-cement blended at early age. Isothermal calorimetry and compressive strength tests were performed on mortars made with various dosages of cement and MK and at different temperatures. 4 mortars prepared with different substitution rates of cement with MK (0, 5, 15 and 25% of cement weight, noted MK0, MK5, MK15 and MK25, respectively). The results have shown that the increase in curing temperature caused an acceleration of the hydration rate and particularly an earlier appearance of the main peak of hydration. The compressive strength results also enabled to detect an optimal content of MK giving the higher mechanical performances, which was dependent on the age of the mortars.

Chloride transport through cementitious membranes using pulsed current

B. Díaz, X.R. Nóvoa, B. Puga and V. Vivier

Microstructural changes and chloride transport in cement pastes are studied under DC current and pulsed electric fields. Impedance Spectroscopy and Ultrasonic Pulse Velocity measurements have been employed for quasi-real time monitoring of changes in the cement paste microstructure. The results show that the electric resistivity and ultrasound velocity (measured at 500 kHz) are modified during the migration experiments. At the end of test, Mercury Intrusion Porosimetry reveals an important increase in the gel pores. The experimental results show a conduction enhanced through gel pores. The use of pulsed current is presented as an alternative method to minimize the negative effects produced by DC current.

Ductility of damaged reinforced concrete beams

José Santos and A. Abel Henriques

In this paper the experimental campaign to quantify the ductility of reinforced concrete beams with damaged rebars is described. The ductility of these beams were analysed for different degrees of corrosion, being observed that pitting corrosion up to 10% has not influenced the rotation capacity.

Concrete building in marine environment – prevention of chloride induced reinforcement corrosion

Naïma Touloum and Ahmed Brara

In this contribution, the predictive theory of structure life based on durability indicators is adopted to study concrete just before and after its placement in an aggressive marine environment. For this purpose, a building under construction on Algiers coastline was chosen as a case study. According to the environmental conditions of the designed structure, the two durability indicators selected are the accessible to water porosity and chloride ions ingress coefficient. The indicators determined on concrete samples moulded before placing and cored from the structure at an early age (few months) are found significantly different.

Effect of microclimate on the durability of concrete structures

A. Belarouci, F. Ghomari, A. Khelidj and A. Bezzar

In Sea front, the chlorides remain the main cause of the deterioration of coastal structures reinforced concrete immersed by seawater. These conditions are largely due to the corrosion of steel reinforcement which are popping concrete coating. In this article, we measure, in the laboratory, the coefficient of diffusion of ions chlorinated in saturated concrete samples through accelerated, migration tests to determine the apparent diffusion coefficient Show the NT BUILD 492. However to simulate the reality of the climate conditions that are variable, we studied the effect of temperature on the phenomenon of transfer of these ions in concrete material in the range 0 to 40 ° C.

Theoretical and experimental study of the shear beams reinforced with bars fiber glass

W. V. Beiral, S.G. Gonzales and D.P. Dias

This work aimed to evaluate the behavior of beams strengthened by shear with bars polymers reinforced fibers of glass. The experimental program consisted of characterization tests of materials and manufacture four beams of rectangular cross section of 45 cm x 15 cm, with fck of 30MPa. Strengthening with GFRP reinforcement, significantly increased the shear capacity of reinforced concrete beams of 80.7 MPa to 160.7 MPa in the American standard, and 108.71 MPa to 284.21 MPa in the Brazilian standard. GFRP bars have the potential to boost the market, however you need to invest in further research will confirm that its many benefits, reducing its cost to expand its use.

Theme B

Assessment
& Inspection

SESSION B1

May 31 th	Chairpersons: Luís Oliveira Santos and Joana Sousa Coutinho	
11:45-12:00	<u>P.Pereira</u> and A.Costa	Concrete structures durability design – probabilistic approach
12:00-12:15	V. Garnier, <u>Z.M Sbartaj</u> , JP Balayssac, X Derobert, D. Breysses, B. Piwanowski, J. Salin and V. Fardeau	Analysis and capitalisation for the diagnosis of constructions
12:15-12:30	<u>Jorge Rodrigues</u> and Maira Ledesma	Dynamic tests of a bridge with the deck retrofitted with external pre-stressing
12:30-12:45	<u>António Costa</u> , Júlio Appleton, Zita Lourenço and Manuel Coito	Durability assessment of concrete structures in marine environment – case studies
12:45-13:00	<u>João Santos</u> , André D. Orcesi, Paulo Silveira and Weichao Guo	Real time assessment of rehabilitation works under operational loads
13:00-13:15	<u>António Santos Silva</u> , Dora Soares, João Custódio and António Bettencourt Ribeiro	Prognosis of internal expansive reactions in concrete structures

Concrete structures durability design – probabilistic approach

P.Pereira and A.Costa

The durability of concrete structures has been a subject of increasing concern in the last decades. Studies have identified the reinforcement corrosion as the main responsible for the premature degradation of concrete structures, mainly due to the environmental exposure to the carbonation or chloride penetration action.

It was developed in this context, a computer program that allows the user to perform durability analysis of concrete structures using a performance-based methodology with a full probabilistic approach through the durability safety concept of the Lifetime Design.

Analysis and capitalisation for the diagnosis of constructions

V. Garnier, Z.M Sbartai, JP Balayssac, X Derobert, D. Breysse, B. Piwanowski, J. Salin and V. Fardeau

Non Destructive Testing backs up the diagnosis and maintenance of construction works. It aims to evaluate some characteristic data of the concrete and of the structure on large scales through targeted durability indicators. The latter account for the condition and ageing of the material. Their evaluation by means of non destructive techniques is currently mastered in laboratory. Yet transferring this control onto site raises a number of questions to take into account the history of the work, the local context of the material and of the environmental conditions. The “Analysis and Capitalisation for the Diagnosis of Constructions” project that we are presenting (here) brings forth some answers and a procedure to this problem.

Dynamic tests of a bridge with the deck retrofitted with external pre-stressing

Jorge Rodrigues and Maíra Ledesma

This paper addresses the evaluation of the structural condition of a bridge based on the experimentally evaluated dynamic characteristics. The presented study was developed in a pre-stressed concrete bridge with more than 30 years of service, which was retrofitted with external pre-stressing of its deck. This structural intervention was performed after studies and inspections that detected the existence of several deficiencies, including cracks in the longitudinal beams of the deck, as well as cracks in the base and footing of some piers. In the paper the dynamic tests are described and the identified dynamic characteristics are compared with the ones computed with a finite element model of the bridge.

Durability assessment of concrete structures in marine environment – case studies

António Costa, Júlio Appleton, Zita Lourenço and Manuel Coito

This paper presents the durability assessment of several concrete structures of an industrial complex exposed to marine environment. The structures were inspected and tests were performed in order to get information on the material resistances to assess the durability and define the preventive measures to control the deterioration mechanisms.

Durability assessment was based on prediction degradation models related to reinforcement corrosion caused by chloride and carbonation defined in LNEC E 465 specification. The performed durability analysis was probabilistic based using the statistical information referred in fib bulletin 34.

Real time assessment of rehabilitation works under operational loads

João Santos, André D. Orcesi, Paulo Silveira and Weichao Guo

Rehabilitation and retrofitting can produce effects on structures which may not always be entirely predicted. Structural health monitoring can be of good use during bridge works, which are generally carried without traffic interruption. In this work a technique based on cluster analysis is used to classify structural states before, during and after repair works on a bridge in Mozambique. This approach allows concluding about the influence of repair works under regular traffic and it can be applied for real time structural health monitoring, during the structure's life cycle or repairing works.

Prognosis of internal expansive reactions in concrete structures

António Santos Silva, Dora Soares, João Custódio and António Bettencourt Ribeiro

In the last decade, there has been in Portugal a large number of concrete structures deteriorated, in which were diagnosed internal expansive reactions (IER), particularly the ASR (alkali-silica reaction) and ISR (internal sulphatic reaction). The knowledge of an increasing number of affected structures has been a result of greater consciousness of the national technical means for this type of degradation of concrete structures, as well as the improved of characterization methods used for their diagnosis. However, in addition to a correct diagnosis, it becomes increasingly important to implement prognostic means to predict the potential reactivity still exists in the concrete structure affected.

This paper aims to present recent studies of prognosis, performed at LNEC, on concrete structures affected by IER, illustrating the characterization methodology employed.

SESSION B2

May 31 th	Chairpersons: Franck Schoefs and Maria João Correia	
17:00-17:15	<u>Raelize du Plooy</u> , Azadeh Attari, Ciaran McNally, Mark Richardson, Sergio Palma Lopes, Géraldine Villain and Xavier Déroberti	Destructive and non-destructive condition assessment of a 100 year old concrete bridge
17:15-17:30	Laurent Van Parys, Fabrice Dagrain and <u>Laurent Léoskool</u>	The recourse to cutting-based tomography for quantifying the surface strengthening of altered stones
17:30-17:45	<u>Géraldine Villain</u> , Xavier Dérobert and Amine Ihamouten	Proposal of a calibration protocol to determine the concrete water content on site with Non Destructive capacitive technique
18:00-18:15	<u>Madalena Teles</u>	Petrographic study of concrete. A contribution to a european standard
18:15-18:30	<u>F. Schoefs</u> , T. V. Tran, , E. Bastidas-Arteaga, G. Villain, X. Derobert, A.J. O'Connor and S. Bonnet	Optimization of non destructive testing when assessing stationary stochastic processes: application to water and chloride content in concrete

Destructive and non-destructive condition assessment of a 100 year old concrete bridge

Raelize du Plooy, Azadeh Attari, Ciaran McNally, Mark Richardson, Sergio Palma Lopes, Géraldine Villain and Xavier Dérobert

The durability of cover concrete is the controlling factor in determining the rate at which corrosion initiation takes place within steel reinforced concrete structures. Various destructive and non-destructive techniques are available to assess corrosion risk and to monitor the ingress of aggressive agents such as chlorides. This paper presents results from a concrete condition assessment of a 100 year old bridge suffering from severe corrosion using electrical resistivity, capacitometry, radar (non-destructive), iodide migration and electron microscopy (destructive) techniques.

The recourse to cutting-based tomography for quantifying the surface strengthening of altered stones

Laurent Van Parys, Fabrice Dagrain and Laurent Léoskool

Several phenomena may be responsible for the degradation of stones used in masonry structures. In most of the cases, a treatment with chemical products (resin, ethyl silicate...) or natural lime-based preparations may be prescribed for targeting a surface strengthening effect. In such cases, a fundamental key point consists in quantifying the initial alteration of the stones in order to opt for an appropriate solution and, later, in estimating to what an extent the treatment will have been efficient. Transposed from a usage in the petroleum industry, the cutting test is here proposed in combination with a tomography tool that allows visualizing the damage stress before and after treatment with a less few destructive approach.

Proposal of a calibration protocol to determine the concrete water content on site with Non Destructive capacitive technique

Géraldine Villain, Xavier Dérobert and Amine Ihamouten

This paper deals with the evaluation of the water content on concrete structures. The capacitive technique is a non destructive, rapid, easy-to-use method for on site surface testing. The NDT provides the dielectric constant that is link to the water content by using a calibration straight curve depending on the concrete mix. The aim of this paper is to propose a calibration protocol to determine the calibration curve on a few numbers of small cores. The cores are tested on dry and saturated states in an electromagnetic coaxial cell. A power law model is used to fit the cell results and obtain the calibration curve for the studied concrete structure. This protocol is herein applied to 6 different concrete mixes, at 4 water contents.

Petrographic study of concrete. A contribution to a european standard

Madalena Teles

Almost all of the Technical Specifications for the rehabilitation and/or the strengthening of a concrete structure require not only the physical and chemical characterization of the concrete but also a petrographic study to evaluate the state of hydration of the cement paste, to assess the portlandite supply and to identify the neoformation products. However, results of studies from different authors are sometimes of unequal quality and reliability. To avoid these unconformities, based on the experience and on the analysis of some common mistakes, a list of important principles and procedures is made with the aim of contributing to a European standard which can make these studies easier and more consistent.

Optimization of non destructive testing when assessing stationary stochastic processes: application to water and chloride content in concrete

F. Schoefs, T. V. Tran, E. Bastidas-Arteaga, G. Villain, X. Derobert, A.J. O'Connor and S. Bonnet

The localization of weak properties or bad behaviour of a structure is still a challenge for the improvement of Non Destructive Testing (NDT) tools. In case of random loading or material properties, this challenge is arduous because of the limited number of measures and the quasi-infinite potential positions of local failures. The paper shows that the stationary property is sufficient to find the minimum quantity of NDT measurements and their position for a given quality assessment. A measure of the quality is suggested and the illustration is performed on a one-dimensional Gaussian stochastic field for two supports: water content assessment by capacitive NDT tools and chloride ingress by semi-destructive measurements.

Theme C

Repair

SESSION C1

May 31 th	Chairpersons: Sylvie Yotte and António Santos Silva	
11:45-12:00	<u>Laurent Léoskool</u> , Laurent Van Parys and Sophie Rouge	Compatible mortar for masonry restorations: discrete optimization for equivalent strength & colour prescription
12:00-12:15	<u>M. R. Veiga</u> , A. Santos Silva, M. Tavares, A. R. Santos and N. Lampreia	Durable mortars of a portuguese military structure from the XVI th century
12:15-12:30	<u>A. Gameiro</u> , A. Santos Silva, R. Veiga, A. Velosa, P. Faria	Lime-metakaolin mortars for historical buildings repair: study of the hardening reaction
12:30-12:45	<u>C. Borges</u> , A. Santos Silva and R. Veiga	Role of aggregates in air lime mortars durability: influence of curing conditions
12:45-13:00	<u>P. Faria</u> , V. Silva, J. Grilo, D. Mergulhão, R. Antunes, J. Carneiro, T. Branco, A. Santos Silva and R. Veiga	Lime-based mortars for rendering and repointing
13:00-13:15	<u>F. Cunha</u> , S. Rana, G. Vasconcelos R. Figueiro and S. Abreu	Retrofitting masonry infill walls with novel fibrous structures

Compatible mortar for masonry restorations: discrete optimization for equivalent strength & colour prescription

Laurent Léoskool, Laurent Van Parys and Sophie Rouge

Masonry is a smart building system that has been used for centuries in many places around the world. Therefore, most of the rehabilitation processes concerning master pieces of our Heritage have definitely to consider a fundamental specificity associated with masonry conservation: the compatibility of the repair mortar with the existing structure. As a not sufficient compatibility may be achieved, specific pathologies will strongly impact the intervention. The present paper describes a computer-aided framework having recourse to an elitist genetic algorithm in order to establish a mortar formulation allowing a targeted compressive strength as well as a targeted colour to be achieved.

Durable mortars of a portuguese military structure from the XVIth century

M. R. Veiga, A. Santos Silva, M. Tavares, A. R. Santos and N. Lampreia

In coastal areas of Portugal, many historical buildings and fortresses exist which are constructed of masonry based in air lime mortars. These mortars are often still in good condition, specially showing good cohesion and adhesion to the background, although they usually present degradation on the surface, as a result of the sea aggressive environment.

The purpose of this paper is to present and characterize the mortars and plasters solutions of one of these fortresses, with different periods of construction. The study of the mortars permitted to identify a chronology of periods of construction, to improve the knowledge of the evolution mechanisms of air lime mortars and to choose compatible repair solutions.

Lime-metakaolin mortars for historical buildings repair: study of the hardening reaction

A. Gameiro, A. Santos Silva, R. Veiga, A. Velosa, P. Faria

Formulation of mortars with adequate durability and strength is nowadays one of the major challenges in historical buildings repair. Pozzolanic materials have been used during centuries in air lime mortars to improve their mechanic and durability characteristics.

This paper is part of an extensive work being developed in Portugal, aiming to characterize lime-metakaolin mortars to be employed for historical buildings conservation and repair.

This paper presents the results of hardening reaction study until 90 days of curing. The results show that the hydration reaction occurs mostly for early ages of curing (28 days) while the carbonation reaction is mostly dominant for longer ages (90 days).

Role of aggregates in air lime mortars durability: influence of curing conditions

C. Borges, A. Santos Silva and R. Veiga

Ancient mortars have proved to be durable and reliable materials even when submitted to severe salts in humidity conditions. This study intends to contribute to the rediscovery of the role of aggregate on the durability of lime mortars, namely in terms of its mineralogy characteristics. Thus, several lime mortar compositions were prepared with different kinds of sands and subjected to salty exposure conditions simulating maritime environments. These mortars were followed by physical, mechanical, mineralogical and microstructural characterization.

Lime-based mortars for rendering and repointing

P. Faria, V. Silva, J. Grilo, D. Mergulhão, R. Antunes, J. Carneiro, T. Branco, A. Santos Silva and R. Veiga

Air lime and natural hydraulic lime are compatible but different binders for mortars to be applied on ancient construction protection. The use of pozzolans, as metakaolin, is studied in order to evaluate mortar durability and adequacy to different types of applications. The curing conditions have an important influence on mortar characteristics.

Retrofitting masonry infill walls with novel fibrous structures

F. Cunha, S. Rana, G. Vasconcelos, R. Figueiro and S. Abreu

The present work reports the development of novel retrofitting materials based on braided fibrous structures for the non-load bearing masonry walls. Masonry wall specimens were built with traditional perforated clay bricks, embedding three different types of braided structure and glass/epoxy laminates respectively and were characterized for flexural properties. According to the experimental results, best ductile behaviour was achieved in case of masonry wall retrofitted with the braided structure having carbon fibre core. This demonstrates the better performance of this type of fibrous structure as compared to conventional glass/epoxy laminates in sustaining the structure of masonry infill walls.

SESSION C2

May 31 th	Chairpersons: Rita Moura and Xavier Dérobert	
14:45-15:00	<u>M. Vieira</u> and A.R. Bettencourt	Self-compacting concrete technology as a competitive repair option
15:00-15:15	<u>António Bettencourt Ribeiro</u>	Shrinkage-compensating concrete: behavior at early age and long term of commercial products
15:15-15:30	<u>Tânia Dias</u> , Orlando Pereira, Maria Sofia Ribeiro and Elsa Pereira	Polymer cement mortar in repair. Action on corrosion rates
15:30-15:45	<u>M. Želinková</u>	Inorganic protective coatings for durability of concrete
15:45-16:00	<u>Liliana Baltazar</u> , Maria Paula Rodrigues and João Ramôa Correia	Concrete hydrophobic protection: short-term performance and durability
16:00-16:15	<u>Ahmed El Shami</u> , Stéphanie Bonnet, Marta Choinska, Pierre Mounanga and Abdelhafid Khelidj	Predicting long-term durability of steel reinforced concrete with corrosion inhibitors

Self-compacting concrete technology as a competitive repair option

M. Vieira and A.R. Bettencourt

Self-compacting concrete (SCC) may substitute normal concrete in most structural applications. Nevertheless, the interesting repair applications are those in which SCC can be effectively more competitive, both technologically and economically. Indeed, most repair works are done in locations where it is difficult to vibrate, for instance, in narrow places. These works demands properties not generally considered for new works, namely a small maximum aggregate size to allow flow in the restricted spaces between parent concrete, reinforcement and formwork. This restriction leads to the conclusion that self-compacting mortars can be advantageously used in many repair situations.

Shrinkage-compensating concrete: behavior at early age and long term of commercial products

António Bettencourt Ribeiro

Shrinkage-compensating concrete is usually used to minimize cracking caused by shrinkage. This type of concrete is recommended in structural and non-structural repairs, when there are internal or external restraints of the concrete elements. Commercial products are available which include concrete based on expansive cements and concrete made with shrinkage reducing admixtures. This study evaluates the behavior of two commercial products, not only at early age but also up to about 2 years. Both in sealed and submerged environments, the results indicate an appropriate behavior between demoulding and the first weeks, but, after that, a consistent and relevant increase of shrinkage was observed.

Polymer cement mortar in repair. Action on corrosion rates

Tânia Dias, Orlando Pereira, Maria Sofia Ribeiro and Elsa Pereira

The action of styrene-butadiene (SB) and acrylic-styrene (AS) polymer additions on the corrosion rate of steel embedded in carbonated cement mortar were evaluated by current intensity in high humidity environments. The results of polymer cement mortars (PCM) were compared with those of an unmodified cement mortar (CM) and discussed. These results were additionally confronted with the air content, water absorption, resistance to carbonation, and electrical resistivity. The microstructure of the corrosion products was characterised by scanning electron microscopy (SEM). Results confirmed a noticeable reduction in the corrosion rate of steel rebars embedded in carbonated PCMs comparatively to unmodified CM.

Inorganic protective coatings for durability of concrete

M. Želinková

The article presents a comprehensive summary of the extensive studies conducted to prolongation of the service life of concrete structures using protective coatings. It presents the state of the art of the concrete surface protection, as well as various methods of surface protection. It focuses on the coating systems, their classification and specific requirements. Currently mainly more expensive materials based on epoxides, acrylics and polyurethanes are available on the market. Experts draw the attention to the advantageous inorganic system. Therefore, geopolymer seems to be an useful material for protective coating of concrete.

Concrete hydrophobic protection: short-term performance and durability

Liliana Baltazar, Maria Paula Rodrigues and João Ramôa Correia

This paper presents results of an experimental study about the short-term performance and durability of concrete hydrophobic protection systems. Two hydrophobic surface impregnations and two water-repellent admixtures were applied on concrete specimens with two different water/cement ratios (0.45 and 0.70). In a first stage, the short-term performance of those protection systems was evaluated through a set of experimental tests suggested in EN 1504-2. Subsequently, the durability of the hydrophobic protection systems was assessed by performing the same tests in specimens exposed to artificial accelerated ageing in a QUV chamber up to 1500 hours.

Predicting long-term durability of steel reinforced concrete with corrosion inhibitors

Ahmed El Shami, Stéphanie Bonnet, Marta Choinska, Pierre Mounanga and Abdelhafid Khelidj

One way of protecting embedded steel reinforcement from chloride induced corrosion is by the addition of corrosion inhibiting admixtures. The present study is focused on the most commonly used inhibitors such as ethanolamine (AMA), monofluorophosphate (MFP) and calcium nitrite.

Theme D

Management
& Monitoring

SESSION D1

May 31 th	Chairpersons: Paulo Silveira and Laurent Gaillet	
14:45-15:00	<u>F. Schoefs</u> , K. T. Le and F. Lanata	Assessment of uncertain soil properties for complex infrastructures from monitoring
15:00-15:15	<u>J. Valença</u> , D. Dias-da-Costa, L. Gonçalves, E. Júlio and H. Araújo	Automatic concrete health monitoring
15:15-15:30	<u>Jorge Rodrigues</u> and Máira Ledesma	Monitoring of temperature variations in the Tagus river suspension bridge
15:30-15:45	<u>S. Srinivasan</u> , P. A. M. Basheer, S. Nanukuttan and W. J. McCarter	Use of a multi-electrode sensor to monitor early age properties of concrete
15:45-16:00	Diana Ribeiro, João Almeida Garrett, Sónia Duarte, Lina Nunes and <u>José S. Machado</u>	Probability of damage in timber structures by monitoring of biological activity - MONITOR project
16:00-16:15	Paul Cahil, Eoin Allen, Alan O'Connor and <u>Vikram Pakrashi</u>	Variation of stress in arch structures due to variable concrete pressure models

Assessment of uncertain soil properties for complex infrastructures from monitoring

F. Schoefs, K. T. Le and F. Lanata

Since several decades, quite a lot of structures have been monitored to analyze their displacement during the works or during the service-life. This paper presents a methodology for identifying soil characteristics from data structural health monitoring, applying for to a wharf with instrumented tie-rods. Loading and soil parameters are modelled as random variables. The modelling is performed through a meta-model fitted on a numerical database obtained from direct simulations on a complex finite element model under PLAXIS software: a quadratic Response Surface Model (RSM) is considered.

Automatic concrete health monitoring

J. Valença, D. Dias-da-Costa, L. Gonçalves, E. Júlio and H. Araújo

With the recent development of low-cost equipment and powerful optical/digital methods, new opportunities are emerging for structural assessment. In this work, a method designated by 'Automatic Concrete Health Monitoring' (ACHM) is presented which aims at automatically characterising and monitoring the state of conservation of concrete surfaces. An additional purpose is also to support the assessment of laboratorial tests in scientific research projects.

Monitoring of temperature variations in the Tagus river suspension bridge

Jorge Rodrigues and Maíra Ledesma

The structural behavior of the Tagus river suspension bridge in Lisbon is monitored by a structural health monitoring system that is being developed and implemented by LNEC. That system includes several temperature sensors that are being used to measure the temperature variations to which the structure is subjected. By presenting some of the results obtained recently, this paper highlights the importance of the environmental load of temperature variations in the structural behavior of a large civil engineering structure like the Tagus river suspension bridge.

Use of a multi-electrode sensor to monitor early age properties of concrete

S. Srinivasan, P. A. M. Basheer, S. Nanukuttan and W. J. McCarter

This paper describes the use of electrical property measurements to study physical and chemical changes occurring within cover-zone concrete during the early stages of hydration (up to 28-days). Concrete samples with different mix proportions have been embedded with sensors which are capable of measuring spatial and temporal changes in electrical resistance and temperature of the concrete. The results obtained from different concrete mixtures indicate that the water-binder ratio and both the dosage and type of mineral admixture influence the measured electrical conductivity and temperature within the cover-zone. Results can be interpreted in terms of setting, hardening and strength development; furthermore, the changes observed in the electrical conductivity could also be used to evaluate drying effects and the convective zone.

Probability of damage in timber structures by monitoring of biological activity - MONITOR project

Diana Ribeiro, João Almeida Garrett, Sónia Duarte, Lina Nunes and José S. Machado

The service life of timber structures is often affected by biological deterioration processes. In Portugal the gross of cases are related with biological degradation by termites or fungi. If detected in an early stage, small scale repairs may solve the causes of the degradation at a reasonable cost. For this to happen it is necessary to develop a network of sensors that could provide a continuous surveillance of the structure and give early signs of possible biological agents or abnormal wood conditions that can promote the deterioration. The present paper reviews the results in this field, having in mind the ongoing studies within the research project MONITOR.

Variation of stress in arch structures due to variable concrete pressure models

Paul Cahil, Eoin Allen, Alan O'Connor and Vikram Pakrashi

When concrete is placed in wet form, it is capable of exerting horizontal pressure. The intensity of the horizontal pressure is dependent on the use of the specific model of pressure. Significant variation is present in the available models of horizontal pressure of wet concrete. Consequently, there can be significant variation of stresses on precast structures when in-situ concrete is placed. In the absence of credible experimental data, this variation of stresses should be investigated to avoid or identify increased stresses. This paper investigates the variation of stresses in a precast arch using a number of wet concrete pressure models. The variation is noted along the cross-section of the arch. The findings are important from constructional and design aspects.

SESSION D2

june 1 st	Chairpersons: Muhammed Basheer and Daniel Dias da Costa	
14:45-15:00	<u>Luís Ribeiro Freire</u> and Carlos Santinho Horta	SGOA – Balance of a cycle of inspections 2007-2011
15:00-15:15	<u>Joana Oliveira Almeida</u> , Paulo Teixeira and Raimundo Delgado	Life-cycle cost optimization in highway concrete bridges management
15:15-15:30	<u>Ana Isabel Silva</u>	Portuguese railway network – bridge inspection and maintenance strategy
15:30-15:45	<u>João Luís Amado</u> and Luís Ribeiro Freire	Testing on bridges within the scope of management of a road network

SGOA – Balance of a cycle of inspections 2007-2011

Luís Ribeiro Freire and Carlos Santinho Horta

The Bridge Management System for the conservation and maintenance of the Estradas de Portugal company assets - SGOA, is a decision support tool implemented with the main objective of prioritize interventions. Since its implementation, in 2006, has provided to the technicians involved in bridges management the possibility of consistent and structured decisions, suitable to the company's reality and aiming the optimization of the available resources. In 2011 the first cycle of major inspections to the set of bridges under de company responsibility was concluded. It is intended to present the evaluation of the results obtained in this cycle of inspections, since this analysis is an important tool for the continuity and evolution of the system.

Life-cycle cost optimization in highway concrete bridges management

Joana Oliveira Almeida, Paulo Teixeira and Raimundo Delgado

To help on structures management decision process, a methodology for life cycle cost minimization on a set of concrete bridges during a medium/long term period of time is presented. The methodology takes in consideration the direct and indirect costs associated to different kind of interventions during bridges life time, uses some Markov Matrices as degradation model and applies a genetic algorithm to identify the optimized intervention plan, considering the available budget and the desired minimum performance level. Data's uncertainty is treated in a probabilistic way and Monte Carlo Method simulation is used to highlight the most important parameters on the optimized solution identification.

Portuguese railway network – bridge inspection and maintenance strategy

Ana Isabel Silva

The Portuguese Railway Infrastructure Company (REFER) has a long tradition in inspection, maintenance and rehabilitation of railway bridges in Portugal. This important aspect makes possible the use of bridges built 130 years ago.

The main objective of this paper is to describe the inspection and maintenance policy followed by REFER, and to present some experience in rehabilitation works.

Testing on bridges within the scope of management of a road network

João Luís Amado and Luís Ribeiro Freire

To achieve an efficient management of the bridges under his responsibility, the company Estradas de Portugal implemented a Management System based on periodic visual inspections. These visual observations allow the identification of structural defects and materials deterioration, leading to a primary diagnosis that, in some cases, requires further confirmation. Simple tests and measurement of some physical and chemical parameters represents a way to confirm a subjective condition appraisal. However, by the required investment, a tests campaign to a vast number of bridges needs an adequate programming. This optimization, regarding the definition of scope and prioritization, will be the issue addressed.

Theme E

Sustainability

SESSION E

June 1 st	Chairpersons: Arlindo Gonçalves and Marta Choinska	
16:30-16:45	<u>Ana Brandão de Vasconcelos</u> , Manuel Pinheiro and Armando Manso	Sustainable energy buildings refurbishment: the need for developing a decision model tool
16:45-17:00	<u>B. Touil</u> , F. Ghomari, A. Bezzar, A. Khelidj and S. Bonnet	Effect of natural pozzolan on local's concrete sustainability
17:00-17:15	Rui Vasco Silva, <u>Jorge de Brito</u> and Nabajyoti Saikia	Influence of the curing conditions on the durability-related performance of concrete with selected plastic waste aggregates
17:15-17:30	Sara de Castro Fernandes and <u>Jorge de Brito</u>	Evaluation of the durability of concrete made with grinded glass aggregates
17:30-17:45	<u>Ana Mafalda Matos</u> , Telma Ramos and Joana Sousa-Coutinho	Sulphate attack on eco mortar
17:45-18:00	<u>R. B. Figueira</u> , E. V. Pereira, C. J. R. Silva and M. M. Salta	Organic-inorganic hybrid coatings for corrosion protection of steel

Sustainable energy buildings refurbishment: the need for developing a decision model tool

Ana Brandão de Vasconcelos, Manuel Pinheiro and Armando Manso

Refurbishment of buildings is appointed in several studies and by different authors as a sustainable measure and an opportunity to improve the energy efficiency of existing buildings. In Portugal, buildings refurbishment activity is increasing and is expected to achieve a significant importance compared to the new buildings construction.

The aim of this article is to demonstrate the need for a decision model tool and the characterization of buildings refurbishment and energy efficiency improvements in order to achieve an optimal economic balance.

Effect of natural pozzolan on local's concrete sustainability

B. Touil, F. Ghomari, A. Bezzar, A. Khelidj and S. Bonnet

Nowadays, in different countries, sustainability has become a requirement for concrete structures such as those located in coastal sites. Our study falls under the context of the search for a sustainable and low environmental impact material, by the valorization of the natural pozzolan of Beni Saf in Algeria.

Influence of the curing conditions on the durability-related performance of concrete with selected plastic waste aggregates

Rui Vasco Silva, Jorge de Brito and Nabajyoti Saikia

In this study, the effects of curing conditions, on the durability-related properties, of concrete mixes containing selected plastic waste aggregates were investigated. The concrete mixes were prepared with replacement ratios of 0%, 7.5% and 15% of natural aggregates by plastic aggregates made of polyethylene terephthalate (PET). The effects of fine and coarse aggregates, replaced separately, as well as of their shape, were also investigated. The manufactured concrete specimens were subjected to outer environment, laboratory environment and wet chamber curing regimes. Tests for shrinkage, water absorption by immersion, water absorption by capillary action, carbonation and chloride penetration resistance were carried out.

Evaluation of the durability of concrete made with grinded glass aggregates

Sara de Castro Fernandes and Jorge de Brito

In this experimental work the durability-related performance of concrete with glass aggregates was investigated. Concrete mixes were prepared with replacement ratios by volume of 0%, 5%, 15% and 20% of natural aggregates by glass aggregates, scoping the replacement of coarse and fine aggregates and both at the same time. The concrete samples produced were cured in a wet chamber. Shrinkage, water absorption by immersion and capillarity, carbonation resistance and chloride penetration tests were performed.

Sulphate attack on eco mortar

Ana Mafalda Matos, Telma Ramos and Joana Sousa-Coutinho

This study concerns the influence on sulphate resistance of mortar with blended cements produced with two types of treated agro-industrial waste materials: biomass fly ash (BFA) and waste glass powder (GP). Silica fume (SF) was also used for comparison. Length changes and microstructure investigation (SEM) of the mortar specimens showed that waste glass powder strongly reduced sulphate damage when compared to reference ordinary Portland cement.

Organic-inorganic hybrid coatings for corrosion protection of steel

R. B. Figueira, E. V. Pereira, C. J. R. Silva and M. M. Salta

This paper presents a summary of the main research achievements in the development, through sol-gel method, of organic-inorganic hybrid coatings for protection of steel substrates against corrosion. A systematic selection of the most relevant contributions was made to give the best picture of the present consolidated know-how and perspectives to further development in this area.

Theme F

Case studies

SESSION F1

May 31 th	Chairpersons: Júlio Appleton and António Ribeiro Bettencourt	
10:00-10:15	Hugo Marques, <u>Diogo Bezerra</u> , Raquel Campos e Matos	Oporto's sports pavilion – refurbishment and rehabilitation project
10:15-10:30	João Pinho, <u>José David</u> , Manuel Lorena and Alexandre Portugal	Strengthening and repair of Lanheses bridge
10:30-10:45	<u>Rui Vaz Rodrigues</u> and Mario Fellrath	The new Swiss Graduate School of Public Administration – case study
10:45-11:00	João Pinho, José David and <u>Ricardo Antunes</u>	Strengthening and repair of Mosteirô bridge

Oporto's sports pavilion – refurbishment and rehabilitation project

Hugo Marques, Diogo Bezerra, Raquel Campos e Matos

After performing well as a sports and multifunctional arena during 60 years, this remarkable building is now going to be renovated and refurbished to become a modern multipurpose facility. The Sports Pavilion's main structural feature is the roof that is a dome made of ribbed reinforced concrete forming a spherical cap covered by copper sheet giving it the characteristic green colour. The structure has been studied and evaluated prior to rehabilitation. A structural assessment and inspection of the building was conducted to evaluate the structure present condition. Static load tests and dynamic tests also took place. Supplementary to these observations a structural analysis was carried out by means of numerical models to find out if the structural elements meet current safety standards and are able to bear the new loading conditions. The present abstract describes the most important findings obtained in this process and the main features of the rehabilitation project.

Strengthening and repair of Lanheses bridge

João Pinho, José David, Manuel Lorena and Alexandre Portugal

Lanheses Bridge is a 1,218 m long structure, with typical spans of 30.0 m, and a width of 11.5 m. The crossing of Lima River is its main design constraint, with nine piers founded on its stream bed. This paper describes the different stages of the project, from the initial bridge inspections and structural evaluation, to the design and construction.

The new Swiss graduate school of public administration – case study

Rui Vaz Rodrigues and Mario Fellrath

This paper describes the structural aspects of the rehabilitation of a reinforced concrete, industrial building from the 1970s that was recycled into the new head-office of the Swiss Graduate School of Public Administration (IDHEAP). Major structural rehabilitation works included the change of spans in reinforced concrete prestressed flat slab for accommodating a new auditorium, increasing the punching shear capacity, changes in the bracing system of the roof steel structure, and definition of a new patio.

Strengthening and repair of Mosteirô bridge

João Pinho, José David and Ricardo Antunes

Mosteirô Bridge is a landmark bridge crossing the Douro River, designed by the famous Portuguese engineer Mr. Edgar Cardoso and built in 1972.

The paper describes the different stages of the project, from the initial bridge inspections and structural evaluation, to the design and construction.

SESSION F2

June 1 st	Chairpersons: Maria do Rosário Veiga and Sree Nanukttan	
9:00-9:15	<u>Pedro Providência</u> , Cristina Borges, Artur Corte-Real, Martha Tavares, Rosário Veiga and A. Santos Silva	The monastery of “Santa Clara-a-Velha” – the importance of the study of the wall coverings for the interpretation of the monument
9:15-9:30	<u>Rodrigo F. Terezo</u> and Carlos Dion de M. Teles	Evaluation of timber structures of Santa Cruz headquarters troop
9:30-9:45	<u>Ioan Pепенar</u>	Two case studies on corrosion damage of bridges
9:45-10:00	<u>Carlos Mesquita</u>	Inspection and testing of durability of the concrete structure of a school’s buildings
10:00-10:15	F. Galeković, L. Marinac, V. Perić, <u>B. Žec</u> , M. Serdar and D. Bjegović	Comprehensive repair study of historic building in downtown Zagreb – case study
10:15-10:30	<u>José Paulo Costa</u> , António Couceiro and Santinho Horta	Repair and conservation works on Tagus suspension bridge
10:30-10:45	<u>Zita Lourenço</u> , Henrique Alves, António Martins and Cruz Ferreira	Cathodic prevention of reinforced concrete structure – Cais do Jardim do Tabaco – Lisbon

The monastery of “Santa Clara-a-Velha” – the importance of the study of the wall coverings for the interpretation of the monument

Pedro Providência, Cristina Borges, Artur Corte-Real, Martha Tavares, Rosário Veiga and A. Santos Silva

Since its dedication in 1330, the Monastery of “Santa Clara-a-Velha” in Coimbra (Portugal) has been regularly flooded by Mondego River, and as a result, the ground floor of the building was gradually raised. The existing pavement and façade coverings, namely, plasters, mortars, limewashes, mural paintings and tiles, reveal the building modifications performed during several centuries in the buildings environment. This paper presents the characterization of the lime mortars and limewash paintings, revealing their conservation state as well as the execution techniques used in the past.

Evaluation of timber structures of Santa Cruz headquarters troop

Rodrigo F. Terezo and Carlos Dion de M. Teles

The Santa Cruz Headquarters Troop was designed and built in 1739 on the Anhatomirim Island. This Fortress was registered in 1938 as the National Historical and Artistic Heritage. In the 70's and 80's has been restored and now is managed and maintained by the Federal University of Santa Catarina.

The objective of this work consisted in a visual assessment and a withdrawal of wood samples of some structural parts of the roof and floor, for anatomical identification. Also was used non-destructive testing such as ultrasound, resistive and inductive hygrometer.

Two case studies on corrosion damage of bridges

Ioan Pepenar

The paper presents two cases of steel and prestressed concrete old bridges damaged by corrosion in natural environment with high humidity. Investigation of the damage state of bridge elements, on site and in laboratory, showed major damages due to corrosion of structural elements which affects the resistance, stability and durability of bridges. It also presents the causes and mechanisms of corrosion processes of elements/materials (steel, reinforcement, concrete).

In order to assure normal service conditions of bridges there were proposed intervention measures to remedy existing damages.

Inspection and testing of durability of the concrete structure of a school's buildings

Carlos Mesquita

Following the process of modernization of a school with 30 years of age, the owner requested the development of a diagnostic study of the condition of reinforcement corrosion, the main mechanism of deterioration of concrete structures, supported by inspection and non-destructive tests related to this pathology.

The paper shows the obtained results, its analysis and the conclusions of the diagnostic study, including recommendations for the intervention's strategy to be undertaken (fig. 3 e 4).

Comprehensive repair study of historic building in downtown Zagreb – case study

F. Galeković, L. Marinac, V. Perić, B. Zec, M. Serdar and D. Bjegović

Residential buildings in downtown Zagreb present valuable historical heritage, and create city's visual identity. Their present and future condition is, therefore, of a special concern. In the present paper a comprehensive repair study is presented on a typical residential building, which takes into account the main recognised problems of historical downtown buildings in Zagreb. For all groups of recognised deterioration problems several alternatives are presented and evaluated on the basis of their life-cycle cost. A comprehensive repair model, as presented on the example, could be used for strategic management and maintenance of these structures, enabling optimisation of the governmental resources.

Repair and conservation works on Tagus suspension bridge

José Paulo Costa, António Couceiro and Santinho Horta

Completed in 1966, the magnificent Bridge over Tagus, also known as 25th April Bridge, is still one of the most important accesses to the city of Lisbon nowadays. Maintenance works have been successfully implemented on Tagus Suspension Bridge concerning both its metallic and concrete structural and construction elements. This paper presents the most relevant aspects of the repair and conservation works that pertain to the Bridge maintenance program and actions with respect to durability and appearance. The works were awarded by "Estradas de Portugal, SA", the general concessionaire of the Portuguese Road Network, to a consortium of two Portuguese companies: AMAL and STAP.

Cathodic prevention of reinforced concrete structure – Cais do Jardim do Tabaco – Lisbon

Zita Lourenço, Henrique Alves, António Martins and Cruz Ferreira

Chloride induced corrosion of the reinforcing steel is one of the major causes of concrete structures lifetime reduction, when exposed to marine environment. Cathodic protection (CP) systems are now recommended for new reinforced concrete structures that are to be exposed to such environments. These prevention systems are installed during construction to prevent corrosion of the reinforcement. This paper describes the design, installation and commissioning of the impressed current CP system installed recently in the new Lisbon Cruise Terminal.

Poster session

SESSION P1

Duratinet technical guide: management of structures

Duratinet WG2

This communication summarizes part II of the Technical Guide, elaborated within DURATINET project, to support maintenance and repair of steel structures. The main topics include general guidelines on the management of structures and on the planning of maintenance and structural assessment.

In-situ techniques for mechanical performance and degradation analysis of rendering walls

L. Almeida Santos, I. Flores-Colen and M. Glória Gomes

Rendering facade are building's elements that frequently require repair, due to the environmental exposure to which they are subjected during the life cycle. Thus, the degradation of external walls must be evaluated in real conditions with adequate methods of assessment. In-situ testing techniques, such as thermography, ultra-sounds and rebound hammer, can help the in-service diagnosis when used simultaneously. This paper aims to characterize the potential and feasibility of each in-situ technique and how this data can complement visual inspection in real conditions.

Shear reinforcement in concrete beams with vertical stirrups embedded

Anderson Augusto Mülher, Fábio Costa Magalhães, Letícia Ramos Berr, Cristiane Arpino Silva, João Luis Campagnolo and Denise Carpena Coitinho Dal Molin

The fissures are part of a group of pathologies responsible for the greatest concerns in a building. This paper approach a specific type of fissures, related to shear stress. The goal of this work is to present the results of the experimental analysis of a system of structural reinforcement in concrete beams when submitted to shear effort. Was used vertical stirrups embedded in the high performance mortar. As the result page, we present the viability of the reinforcement system studied. The increase of shear strength obtained was 112% and 90% for the intact and fissured beams, respectively.

Evaluation by visual inspection technique of “hauff type” timber roof structure at “São Carlos Clube” gymnasium in Brazil

Leandro Dussarrat Brito and Carlito Calil Junior

This paper evaluates the current safety condition of “Hauff” type roofing timber structure performed by “Tekno” at “São Carlos Clube” gymnasium in São Carlos, SP, Brazil, inaugurated on November 4, 1952. Recently, a rupture in an inclined beam type timber coffin occurred. Before that, in order to identify the cause of the rupture of main beam and pathologies found throughout the structure of existing roof, it was necessary to develop a technical report, aiming at suggesting corrective measures for maintenance and reinforcement of structural elements. The methodology used for the analysis of structural elements was the non-destructive technique (NDT) of visual inspection.

Parameters affecting on site corrosion rate evaluation

E. Marie-Victoire, V. Bouteiller, J. Montout, J-L. garciaz and E. Cailleux

Reinforced concrete is a world-wide widespread building material, some countries are even listing concrete buildings as historical. As a consequence, when decays appear, they constitute both economical and cultural important issues. One of the most deleterious alteration process of reinforced concrete is rebar corrosion, which can lead to heavy loss of material by spalling. Consequently on site corrosion monitoring, especially at early stage of corrosion is essential. This study, based on 3 years of monitoring of reinforced concrete slabs exposed outdoors, evidenced the influence of parameters such as concrete cover, concrete pollution (carbonation, chlorides), or monitoring device. It also was shown that a rain event was more influencing than the seasons. Finally, some data on corrosion kinetics related to concrete pollution were collected.

Evaluation by visual inspection technique of the pedestrian suspension bridge at Piracicaba in Brasil

Leandro Dussarrat Brito and Carlito Calil Junior

This paper presents the criteria used to evaluate the structural elements of the “Pedestrian Suspension Bridge” in the city of Piracicaba, Brazil, using the non-destructive technique (NDT) of visual inspection. During the survey, suspension devices (such as cables, hangers, anchors), two steel towers, metal guard rails, reinforced concrete piers, and the timber structural elements, such as stiffness of the two flat, all the beams and the deck were investigated. This methodology, aimed at identifying and evaluating the main pathologies found in each element. Depending on the individual symptoms of pathologies detected, corrective recommendations for maintenance and reinforcement were made.

Duratinet technical guide: maintenance and repair of steel structures

Duratinet WG4

This communication summarizes part III of the Technical Guide, elaborated within DURATINET project, to support maintenance and repair of steel structures. The main topics include durability factors and requirements, deterioration processes and related defects, testing techniques for inspection, repair methods, and corrosion protection systems.

Duratinet technical guide: maintenance and repair of concrete structures

Duratinet WG3

This communication summarizes part IV of Technical Guide, elaborated within the DURATINET project, to support maintenance and repair of concrete structures. The main topics include durability factors and requirements, deterioration processes and related defects, testing techniques for inspection and the repair methods.

BEVOTEC12 – a novel biocide for mural paintings and cultural heritage conservation

Tânia Rosado, Patrícia Carvalho, Dora Teixeira, J. Mirão, A. Candeias and A.T. Caldeira

Microorganisms are involved in biodeterioration processes and may cause severe damage in mural paintings, such as discoloration of the painting and detachment of the paint layer. The microbiological study of selected mural paintings suffering from biodegradation processes, allowed to identify the microbial communities responsible for the biodegradation. Different commercial biocides (Preventol PN, Panacide, Linquad) and a new biocide of lipopeptide nature (BEVOTEC12), produced in our laboratory, were tested to control the propagation of these microorganisms, to contribute for an efficient conservation of the mural paintings.

Rehabilitation of a chloride contaminated concrete structure through desalination

Raquel Paula, Pedro Colaço and Zita Lourenço

Electrochemical techniques have been successfully used to treat concrete affected by corrosion and represent effective and durable alternatives to conventional repair methods. This paper outlines the desalination treatment works that were done at parts of a school building, which were severely damaged by reinforcement corrosion caused by chloride contamination of concrete, in view of its rehabilitation.

SESSION P2

Evaluation and modelling of concrete variability using NDT techniques

N. T. Nguyen, Z. M. Sbartai, D. Breysse, J-F. Lataste and F. Bos,

This paper presents the methodology of evaluation and modeling the variability of concrete on a testing site and on existing structures. This methodology enables assessing the reliability of non-destructive testing (NDT) measurements and the concrete variability. A large experimental programme was implemented which consists in NDT measurements (ultrasonic, electrical resistivity, rebound hammer, and radar) on concrete slabs ($2*2.45*0.2\text{m}^3$) of different strengths (25 to 45 MPa). The results of this study show that NDT techniques are potential tools for assessing the variability of concrete in real condition.

Innovative solutions for the use in concrete of excavated materials from Lyon-Turin railway link tunnel

Jérémy Colas, Thierry Chaussadent, Loic Divet, Stéphane Lavaud, Jacques Burdin and Nathalie Monin

Within the framework of the future railway link between Lyon (France) and Turin (Italy), it is proposed to use the highest part as possible of tunnel excavated materials as concrete aggregates. This objective will permit to prevent the excavation of new quarries, to limit the transport by road of excavated materials, and to avoid their definitive storage. However, these materials contain high sulphate content which requires to properly define their potential for use as aggregates. The study carried out leads to consider that several solutions can be proposed as washing materials before use, choosing appropriate cement, or using the excavated materials as a source of sulphates to control cement hydration.

A new research program on FCC in cement mortars for structural repair

Nuno Brito, Carla Costa and Maria Sofia Ribeiro

Structural repairs are a constant reality in national construction work programs, as a result of aging, structural deficiencies, or poor execution. The main causes of failures observed during the repair works, are the repair material quality, the control in the application of repair materials and the knowledge / maintenance of their performance in the service life. This paper presents the research program in the area of sustainability, which aims to study the feasibility of using an oil industry residue, in particular FCC catalyst waste (Fluid Catalytic Cracking) in cement mortars to be employed in the repair of concrete structures. The analysis of the performance requirements (water absorption by capillarity, substrate adhesion, carbonation resistance, chloride diffusion, oxygen permeability and expansion due to alkali silica reaction) of cement mortars incorporating the FCC waste will be according to the specifications defined by European standards (EN 1504).

Polymer action on the alkali-silica reaction in cement mortar bars – damage assessment

João Feiteira and Maria Sofia Ribeiro

Both rapid (28 days) and slow (up to 11 months) alkali-reactivity tests were conducted on bars of different polymer-modified cement mortars (PCMs). The slow alkali-reactivity test was shown to be more suited for the accurate assessment of the performance of polymer-modified cement materials. Despite higher expansion of PCMs in the rapid test, SEM images showed apparent lower microcracking intensity compared to an unmodified cement mortar (CM). Quantitative assessment of microcracking intensity due to ASR is currently being achieved through stiffness damage tests (SDTs) and the results will be available on the final manuscript.

Review and discussion of polymers in cement materials for the repair of concrete structures

Maria Sofia Ribeiro and Augusto Gomes

This article addresses the application of polymers in cement materials for the repair of concrete structures. It summarises the research and development history of the use of polymers to modify the properties of cement materials and the present status of the major standardization work as refers to test methods and quality requirements for polymer cement concrete/mortar. The future trends in the research and development activities of polymer cement materials seem to be focused on the sustainable construction materials and on the use of water-soluble polymers as polymer cement modifiers. Some relevant aspects are also discussed in an approach to repair structures.

Capillary pore volume and water absorption of polymer-modified cement mortars

João Feiteira and Maria Sofia Ribeiro

The capillary pore volume of polymer-modified cement mortars (PCMs) based on a variety of polymer dispersions was assessed through mercury intrusion porosimetry (MIP) tests. The results were compared with those of an unmodified cement mortar (CM) and their accuracy was discussed. MIP results were additionally confronted with the capillary water absorption and the hydration degree of the respective mortar samples. It was found that polymer influence on the total capillary pore volume was not specific of polymer type, and PCMs were found with both lower and higher pore volume than the unmodified CM. A strong correlation between pore volume and capillary water absorption was observed only for the larger capillary pore sizes.

Duratinet project: typology of infrastructures and maintenance stakes along french atlantic coasts

F. Schoefs, A. Audouin-Dubreuil and A. Dary

This paper summarises the results of a questionnaire broadcast in France and prepared within the Duratinet project. It aims to get a better knowledge of the patrimony of public structures in the Atlantic Area. The practices of maintenance and futures stakes are also in the filed of this enquest. Both quantitative and qualitative results are presented herein.

g and preparing surfaces, schemes of initial protection and maintenance measures, laboratory testing of coating systems, as well as the execution and supervision of the work), we are deliberately restricting ourselves here to Part 5 of the standard, "Coating systems", which was revised in January 2008.

Nanostructured coatings for metallic construction materials protection

I.Rute Fontinha, M. Manuela Salta and Mário G. S. Ferreira

Nanostructured coatings exhibit a high potential for corrosion protection of metallic materials, namely, the hybrid sol-gel coatings due to the synergic effect on the mechanical and chemical properties achieved by interconnecting organic and inorganic components. In this study, a nanostructured hybrid sol-gel coating with optimized anticorrosive properties was developed for protection of an aluminium alloy frequently used in the construction field. Its performance was assessed in different corrosive conditions, showing an effective ability to protect the alloy either individually or integrated an anticorrosive coating system usually applied in architecture, replacing the toxic Cr(VI) based pre-treatments.

Study of concrete made with recycled fine and coarse aggregates

M. Sérifou, Z. M. Sbartai and S. Yotte

This paper deals with the possibility of using fresh concrete waste as recycled aggregates in concrete. An experimental program was implemented based on two variables (% of fine aggregates replacement and % of coarse aggregates replacement). The proportion of replacement was 0%, 50% and 100%. Several mechanical and physical properties were tested as strength and porosity. The results show good correlation between aggregates percentage of replacement and concrete properties.

Technical demonstration

Technical demonstration session

Corrosion protection for steel structures

Helena Beleza

Without long-lasting and truly effective corrosion protection, many steel structures start to look quite old after only a few years. But it's not just the appearance that deteriorates – the strength of the structure can also start to suffer.

Whereas the standard is an 8-part work that goes in great detail into every aspect of corrosion protection (basic principles, environmental influences, assessing and preparing surfaces, schemes of initial protection and maintenance measures, laboratory testing of coating systems, as well as the execution and supervision of the work), we are deliberately restricting ourselves here to Part 5 of the standard, “Coating systems”, which was revised in January 2008.

Refurbishment of roofs using poliurethane based liquid membranes

André Rosa

This presentation will talk about the liquid applied membranes in the waterproofing of roofs.

The focus of this presentation will be the advantages of this kind of products, the way of application, how these products fit to the details on the roofs, the way to control the thickness of the applied membrane and the quality of the whole work. There will be also addressed the actual certificates of this products. Will be also shown some examples of application and references.

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