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Royaume du Maroc
Ministère de la Jeunesse, de la Culture et de la Communication



المملكة المغربية
وزارة الشباب
والثقافة والرياضة

جامعة مولاي إسماعيل
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UNIVERSITÉ MOULAY ISMAIL

كلية العلوم والتقنيات
FACULTÉ DES SCIENCES ET TECHNOLOGIES

The International Meeting on Mediterranean Architectural Heritage (RIPAM10)

Under the theme :

Valorisation and preservation of architectural heritage from natural risks

Book of abstracts

Errachidia, November 2-4, 2023

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Acknowledgement

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CERKAS - OUARZAZATE



Presentation

The International Meetings on Mediterranean Architectural Heritage (RIPAM) are significant scientific events that bring together a distinguished community of researchers, academics, historians, architects, heritage scientists, experts, curators, and professionals from various countries and institutions around the Mediterranean basin, including Morocco, Italy, Portugal, France, Spain, Algeria, and Tunisia.

Since their inauguration in 2005, RIPAM has been held every two years, alternating between the two shores of the Mediterranean. In addition to this year's edition in Errachidia, Morocco had the honor of hosting three editions in Meknes, Marrakech, and Rabat in 2005, 2007, and 2019, respectively. The other editions of RIPAM have shone in Lisbon in 2009, M'Sila in 2012, Marseille in 2013, Tunisia in 2015, Genoa in 2017, and also in Lisbon in 2022. Each edition of RIPAM embodies a celebration of Mediterranean architectural heritage, a knowledge-sharing forum, and an invaluable platform for international collaboration.

The Mediterranean region stands out for its architectural heritage of great richness and diversity, reflecting the ingenuity and creativity of artisans, as well as the cultural depth that characterizes this part of the world. Considering that the construction sector is one of the largest emitters of greenhouse gases, accounting for approximately 39% of carbon emissions and 33% of waste, industry actors have been motivated to replace traditional materials with environmentally friendly materials.

Currently, concerns related to energy and environmental issues in the construction field have led sector players to prioritize the use of eco-materials instead of conventional materials. This trend has sparked renewed interest in construction with local materials in recent years (including earth, stone, wood, among others) due to their durability and very favorable environmental footprint.

Like the oases areas, the Draa-Tafilalet region boasts a remarkably rich and diverse architectural heritage in earth, encompassing structures such as ksours, kasbahs, mosques,

fortifications, and granaries. The restoration of this heritage, beyond its immediate impact on the local community, holds substantial significance for the regional economy, cultural heritage, and the tourism sector. Rehabilitation projects often require the involvement of specialized local labor for construction, restoration, and rehabilitation work. Once restored, these structures become tourist attractions, thereby generating economic benefits for local and regional businesses in the tourism, industrial, and agricultural sectors. They contribute to the preservation and enhancement of the invaluable architectural heritage in earth unique to the region.

Thus, the city of Errachidia, the capital of the region, is a fitting setting to host the tenth edition of the International Meeting on Mediterranean Architectural Heritage (RIPAM10) from November 2 to 4, 2023.

Présentation

Les Rencontres Internationales sur le Patrimoine Architectural Méditerranéen (RIPAM) sont des événements d'envergure scientifique qui réunissent une communauté éminente de chercheurs, universitaires, historiens, architectes, scientifiques du patrimoine, experts, conservateurs et professionnels relevant de différents pays et institutions autour du bassin méditerranéen, du Maroc, de l'Italie, du Portugal, de la France, de l'Espagne, de l'Algérie et de la Tunisie.

Depuis leur inauguration en 2005, les RIPAM se déroulent tous les deux ans, en alternance entre les deux rives de la Méditerranée. Outre l'édition prévue cette année à Errachidia, le Maroc a eu l'honneur d'accueillir trois éditions respectivement à Meknès, à Marrakech et à Rabat en 2005, en 2007 et en 2019. Les autres éditions des RIPAM ont brillé à Lisbonne en 2009, à M'Sila en 2012, à Marseille en 2013, en Tunisie en 2015, à Gênes en 2017 et également à Lisbonne en 2022. Chaque édition des RIPAM incarne une célébration de l'héritage architectural méditerranéen, un forum de partage de connaissances et une plateforme de collaboration internationale inestimable.

La région méditerranéenne se distingue par un patrimoine architectural d'une grande richesse et diversité, témoignant de l'ingéniosité et de la créativité des artisans, ainsi que de la profondeur culturelle qui caractérise cette partie du globe.

Sachant que le secteur du bâtiment et de la construction est l'un des plus importants émetteurs de gaz à effet de serre; il produit environ 39% des émissions de carbone et 33% des déchets. Ceci a incité les acteurs de ce secteur à remplacer les matériaux traditionnels par des matériaux amis de l'environnement.

A l'heure actuelle, les préoccupations relatives aux enjeux énergétiques et environnementaux dans le domaine de la construction ont amené les acteurs du secteur à privilégier l'utilisation d'éco-matériaux en remplacement des matériaux conventionnels. Cette tendance a suscité un regain d'intérêt pour la construction en matériaux locaux au cours des dernières années (notamment la terre, la pierre, le bois, entre autres), du fait de leur durabilité et de leur empreinte environnementale très favorable.

A l'instar des zones oisiennes, la région Draa-Tafilalet abrite un patrimoine architectural en terre d'une remarquable richesse et diversité, englobant des édifices tels que ksours, kasbahs, mosquées, fortifications et greniers. La restauration de ce patrimoine, au-delà de son impact immédiat sur la communauté locale, revêt une portée substantielle touchant l'économie régionale, le legs culturel et le secteur touristique. Les projets de réhabilitation requièrent fréquemment l'implication d'une main-d'œuvre spécialisée au niveau local pour la réalisation des travaux de construction, de restauration et de réhabilitation. Une fois restaurées, ces structures se muent en pôles d'attraction touristique, générant ainsi des retombées économiques pour les entreprises locales et régionales dans les secteurs touristique, industriel et agricole. Elles contribuent de ce fait à la sauvegarde et à la mise en valeur du patrimoine architectural en terre d'une richesse inestimable propre à la région.

Ainsi, la ville d'Errachidia, capitale de la région devient ainsi un cadre propice pour abriter la dixième édition de la Rencontre Internationale sur le Patrimoine Architectural Méditerranéen (RIPAM10) du 2 au 4 novembre 2023.

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Thursday November 2nd		
FST Errachidia		
08:00-09:30	Welcome & Registration	
09:30-10:30	Opening ceremony	
10:30-11:00	Welcome reception	
	Chairperson : Pr. IBNOUSSINA Mounisif - Pr. ALEGRIA José Alberto	
11:00-11:40	Plenary lecture 1 Limam Ali: "Matériaux terre et constructions en terre : Passé, présent et perspectives"	
11:40-12:00	Coffee break	
12:00-12:40	Plenary lecture 2 Boussalh Mohamed: "Les architectures de terre des vallées présahariennes du Maroc : Bilan, résultats et perspectives."	
12:40-13:40	Oral communications : Session 1	
	Dr. FRATINI Fabio	
	KHRISSI Youssef	Experimental study of the reinforcement of unstabilized and stabilized local clay materials with date palm fibers
	BOUCHAHMA Anouar	L'enduit traditionnel de chaux : un bilan
	AKRAM Laila	Fire induced microstructural changes in local building materials: cases of white marble and limestone
	MASROUR Ilham	Investigating the Influence of Natural Pozzolan and Wood Shavings on the Mechanical Properties of Rammed Earth in traditional building
	BOUHIYADI Samir	Modeling Heat and Mass Transfer in Walls of Buildings Constructed with Compressed Earth Blocks
	ABOUBAKAR Moustapha	Studing of the slag addition and sintering temperature for the technological and mechanical properties of dolomite based porous ceramics
	DERUTO Viviana	Wood heritage in the mediterranean construction between tradition and innovation for health and energy saver. The MaVE-Material Value Exposure research
13:40-14:40	Lunch	
	Chairperson : Pr. HADDAD Mustapha - Pr. GONZALEZ Filipe	
14:40-15:20	Plenary lecture 3 Laaroussi Najma: "Réalisation d'une base de données des propriétés thermophysiques utiles des principaux matériaux de construction locaux."	
15:20-16:00	Plenary lecture 1 Moriset Sébastien: "Conservation du patrimoine et construction contemporaine : quels outils pour revenir à des circuits courts ? Conservation des architectures de terre en contexte archéologique"	
16:00-16:30	Oral communications : Session 2	
16:00-16:30	Pr. LIMAM Ali	
	HAJAOUI Mohamed	Restauration architecturale Au-delà de l'incompatibilité physico-chimique des matériaux Problèmes des couleurs et d'esthétique
	PITTALUGA Daniela	Sauvegarde et restauration du patrimoine architectural Palais Fieschi Gênes Sestri Ponente). Consolidation structurale de la voute du salon et restauration structurale des elements muraux dans le cadre de la
	MOCERINO Consiglia	Innovation and resilience in the redevelopment, restoration and digitalisation strategies of architectural heritage
16:30-16:40	Coffee break & Poster session	
16:40-18:00	Oral communications : Session 3	
	Dr. PANCANI Giovanni	
	SOUILEH Ayoub	Assessing the impact of shale from the Settat Khouribga area on concrete properties
	LECHHEB Mahdi	Characterization of the physical and thermal properties of raw earth bricks from Ksar Ait Benhaddou
	EL GHOMARI Azzeddine	Experimental Analysis on Mechanical and Thermal Properties of Wall Mortar Comprising Clay and Reed Fibers from Drâa-Tafilalet Region
	FRATINI Fabio	Characterisation of the materials and construction techniques of Sahrjij Labguar: a thousand-year-old abandoned hydraulic structure (Marrakech, Morocco)

	CHAR Mohamed	Experimental characterization of the thermal and mechanical properties of earth bricks stabilized by alkaline solution and reinforced with renewable palm fibers: a comparative study
	OULIDA Nouhaila	Ancient wall mortars from the mosque of Sijilmassa (Morocco): Raman and ATR-FTIR characterization
	ARKAME Youssef	Physical-chemical and technological characterization of porous ceramics prepared from Moroccan clayey materials
	OUALAL Hassan	Étude comparative de l'élimination des effluents liquides par adsorption et par filtration sur membranes à base d'argiles locales

Friday November 3rd, Delivery of certificates		
FST Errachidia		
Chairperson : Pr. NOUNAH Abderrahman - Pr. PITTALUGA Daniella		
09:00-09:40	Plenary lecture 1: Simou Sana : “Guidelines and Standards for Earth Construction”	
09:40-10:20	Plenary lecture 2 Luís Mateus: “Documentation of Architectural Heritage with Photogrammetry and Laser scanning. Principles and some examples in Portugal.”	
10:20-10:40	Coffee break	
10:40-13:00	Oral communications : Session 4	
	Pr. BABA Khadija - Pr. EL RHAFFARI Younes	
	NAKCOUCH Samia	THE ROLE OF LOCAL POPULATION IN SAFEGARDING HERITAGE : CASE OF CHEFCHAOUEN
	KOURDOU Ibtissam	Preservation of modern cultural heritage in modern cities – case study of Rabat in Morocco
	FREDIANI Pierpaolo	The rehabilitation of the architectural heritage in the Marinella aricultural park
	OBLAK Polona	Préservation du patrimoine local et architectural dans la région de l'Istrie slovène contre les inondations côtières
	EL MALHI Sana	The architectural authenticity of the Tafilalet region: preservation of traditional construction techniques and valorization of local materials
	IMGIRNE Ayoub	Characterization and Potential Applications of Moroccan Lizardite Clay in Ceramics: Technological Evaluation
	KIDARI Rachid	Investigation of the thermomechanical characteristics of compressed earth bricks reinforced with cement and corn straw
	EL HARROUNI Khalid	Traditional earth architecture as a tool for sustainability and adaptation to climate change of heat and cold extremes
	AMMARI Abdelmalek	Thermal, Chemical and Mineralogical properties of soil building blocks for eco-habitat sustainable
	AQELMOUN Nissrine	Physico-chemical and mechanical characteristics of traditional Marrakech lime
	EL HARROUNI Rime	The transition of Moroccan Riads and Dars into new Socio-Cultural and Sustainable Context
	EL MANSOURI Charaf Eddine	Mechanical and thermal characterization of local building materials stabilized by gum arabic in the region from the Drâa-Tafilalet region (southeast Morocco).
13:00-14:30	Lunch	
	Pr. BOUSSALH Mohamed - Pr. EL HAROUNI Khalid	
14:30-15:10	Plenary lecture 3 Razzouk Yassine : “Seismic Resilience in Traditional Construction: Reviewing Construction Guidelines and Strategies for Seismic-Resistant Traditional Structures”	
15:10-16:30	Oral communications : Session 5	
	Pr. EL AMRAOUI Mohamed - Pr. OBLAK Polona	
	LICO Alessia	Seismic Vulnerability Assessment of a building aggregate in the historical centre of Florence
	GONZALEZ Filipe	Stratégies d'auto(re)construction dans un scénario post-catastrophe
	MANSOUR Majid	Matériaux locaux et risque sismique
	ERAZA Najoua	Optimization of the building constructed of Confined Stone Walls according to the Moroccan zoning

	KHLIFATI Oumaima	Object Detection Method for Automated Classification of Distress in Rabat's Built Heritage
	PANCANI Giovanni	Integrated digital documentation for conservation, the case study of the Torre degli Upezzinghi called Caprona, in Vicopisano (PI) Italy
	PARRINELLO Sandro	Traditional Architectures Along the Cultural Route of James I of Aragon in the Province of Valencia: Leveraging Laser Scanning and BIM for Heritage Management
	OUMOU MEN Keltoum	Advancing heritage building conservation through HBIM-based VR
16:30-16:40	Coffee break & Poster session	
16:40-17:40	Oral communications : Session 6	
	Pr. MANSOUR Majid	
	BOUCHARK A	Comparative analysis of the effect of thermal insulation on the energy requirements of a tertiary building in Meknes
	FIKRI Imane	Mortars of mural fragments from al-Qarawiyyin mosque, Volubilis and Banasa sites (Morocco): petrographic and structural analysis
	HADDAJI Younesse	Phosphate mine tailings-based geopolymer composite: Mechanical and thermal behavior
	MAJDOUBI Hicham	Enhancing Geopolymer Properties through Natural Phosphate Additives : Characterization and Performance Evaluation
	ALLAOUI Driss	Sustainable Geopolymer from Ceramic Industry Wastewater Sludge: Mechanical, Thermal, and Chemical Performance Evaluation
	NADI Moad	Effect of decarbonated natural graphite additions on metakaolin based geopolymers: A mechanical and microstructural Study
17:40-18:30	Closing session	

Saturday November 4th	
Cultural Excursion	
A world heritage exhibition in earth and other local materials will be organized by CERKAS.	
An excursion to the Ksours of the Ziz Valley, Erfoud and Risani. The excursion ends with a camel ride over the sand dunes of Merzouga to watch the sunset (fee covers lunch on Saturday and transport to Merzouga).	

Posters session on Thursday & Friday	
Pr. TILIOUA Amine - Pr. BATAN Abdelkrim	
EL OMARI Mohamed	Raman spectroscopy characterization of stone flooring “caçada marble”, in Lisbon, Portugal
CHRACHMY Mohammed	Étude expérimentale et théorique utilisant la méthode DFT pour l'adsorption compétitive de deux colorants cationiques sur une argile de la région Drâa-Tafilalet
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Main Topics

Characterization and physico-chemical and hygro-thermal behavior of architectural heritage materials and Local building materials.

Impact of architectural heritage rehabilitation on the socioeconomic level; sustainable development and investment.

Digital and virtualization of architectural heritage.

Restoration, enhancement and preservation of architectural heritage against natural disasters.

Local building materials: construction techniques between tradition and innovation; production and implementation of local materials; regulatory and normative references and energy efficiency.

Plenary Lectures

Seismic Resilience in Traditional Construction: Reviewing Construction Guidelines and Strategies for Seismic-Resistant Traditional Structures

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Abstract

Traditional constructions, often rooted in age-old practices and locally sourced materials, serve as a reflection of a region's architectural heritage and cultural identity. These long-established construction methods have endured the test of time, embodying historical and sustainable significance. Nevertheless, these construction techniques expose significant vulnerabilities during seismic events, giving rise to concerns regarding the safety of their occupants. Recently, the Alhaouz-Marrakech region experienced a seismic event with a magnitude of 7 on the Richter scale, resulting in substantial material damage, injuries, and even loss of life. These consequences underscore the pressing need to enhance the seismic resilience of traditional structures.

During the earthquake, traditional buildings exhibited their susceptibility to seismic tremors due to the composition of materials used and the lack of structural reinforcement, rendering them prone to severe structural damage and risking occupant safety. Over time, Morocco has developed the "Seismic Regulation for Earthen Constructions" (RPCT 2011); however, inconsistent national implementation has been observed. To bolster seismic resilience in Moroccan traditional construction, measures must be taken to enhance the buildings' ability to withstand seismic shocks. This entails adopting construction techniques suitable for seismic-prone regions and developing earthquake-resistant methods, potentially incorporating wooden or metal structures for reinforcement and employing earth mixtures better suited to seismic requirements. Encouraging locally adapted construction practices that preserve cultural traditions while ensuring resident safety is paramount.

The challenges associated with improving seismic resilience in traditional construction in Morocco are multifaceted, requiring awareness campaigns, local artisan training, and the implementation of appropriate construction standards. Looking ahead, the establishment of policies and practices conducive to seismic resistance is of paramount importance. To ensure effective seismic resilience in Moroccan traditional construction, it is crucial to compare the Moroccan approach with international best practices and experiences from other seismic-prone regions worldwide. Such a comparative analysis aids in identifying the most relevant solutions for strengthening the safety of traditional structures while preserving Morocco's unique cultural heritage.

Keywords: Traditional Construction, Seismic Resilience, Morocco, Earthquake Vulnerability, Cultural Heritage Preservation.

Documentation of Architectural Heritage with Photogrammetry and Laser scanning. Principles and some examples in Portugal

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Abstract:

The presentation is about Architectural Heritage Documentation and specifically about the role that the tools of laser scanning and photogrammetry play in that context.

It is divided into three parts.

In the first part is done a short presentation of ArcHC_3D research group and the framing of the work developed covering realms of the fundamental research, pedagogical practice, and knowledge transfer.

In the second part of the presentation, we will discuss the methods employed from the principles to the tools, the possible outcomes of those methods, when applied to heritage documentation and some examples of outputs and applications, ranging from the typical production of plans, sections and elevations, CAD and BIM models, videos and web outputs..

Finally, in the third part of the presentation it is summarized how these methods of photogrammetry and laser scanning can be used in a systematized way to provide knowledge about reality, namely architectural heritage, in the context of conservation and rehabilitation.

Throughout the presentation many examples of heritage surveys will be presented. A few of these are the survey of Arc of Rua Augusta, in Lisbon, the fortress of Juromenha, in Alentejo, the castle and the park of Vila Viçosa, also in Alentejo, among many others.

Réalisation D'une Base De Données Des Propriétés Thermophysiques Utiles Des Principaux Matériaux De Construction Locaux

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Résumé

Dans un contexte de demande énergétique croissante, le Maroc a adopté une nouvelle stratégie énergétique visant à assurer la sécurité de l'approvisionnement et à maîtriser la demande. L'objectif clair est de réaliser des économies d'énergie de 20% d'ici 2030. Pour atteindre cet objectif, le Maroc a mis en place un plan d'efficacité énergétique dans divers secteurs économiques tels que le transport, l'industrie et le bâtiment. En ce qui concerne spécifiquement le secteur du bâtiment, le Maroc a mis en œuvre un ensemble de mesures pour soutenir sa stratégie de développement énergétique.

Une des actions clés découlant de ce plan est l'adoption du Règlement Thermique de Construction au Maroc (RTCM), qui s'applique principalement aux nouveaux bâtiments. Ce règlement fixe, selon des approches prescriptives et basées sur les performances, les règles de performance thermique de l'enveloppe du bâtiment ainsi que les exigences énergétiques globales. De plus, le "Code d'Efficacité Énergétique dans le Bâtiment", développé par l'Agence Marocaine de l'Efficacité Énergétique (AMEE), complète cette initiative. La création d'une base de données nationale contenant les caractéristiques thermo-physiques des matériaux de construction locaux (comme les briques et les parpaings) disponibles sur le marché marocain était nécessaire pour effectuer les calculs nécessaires à la vérification de la conformité des projets de construction au RTCM.

C'est dans ce contexte que s'inscrit le présent travail, qui met en évidence les résultats du projet de recherche $\lambda@DB$ mené par l'équipe de recherche "Materials Energy and Acoustics Team" (MEAT) de l'École Supérieure de Technologie de Salé. Ce projet a été réalisé dans le cadre d'une convention de recherche signée entre l'Université Mohammed V de Rabat et l'Agence allemande de coopération internationale (GIZ).

Conservation du patrimoine et construction contemporaine : quels outils pour revenir à des circuits courts

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Résumé

La prise de conscience de la pertinence des matériaux locaux pour édifier des architectures à faible empreinte écologique a amorcé un rapprochement entre artisans locaux, conservateurs du patrimoine et concepteurs d'édifices nouveaux. Le monde des architectes s'ouvre graduellement à une nouvelle approche de la conception architecturale qui accepte avec humilité de faire avec ce qui est disponible autour du lieu de construction, tant sur le plan matériel que sur le plan social ou culturel. Mais comment faire avec la terre, la paille ou la pierre quand on a été formé au béton armé ? La réponse se trouve bien souvent dans les vestiges du passé et dans la collaboration entre gens de métier. De nombreux projets architecturaux vantant aujourd'hui les mérites de l'approche vernaculaire se revendiquent de l'intelligence d'édifices anciens qui les ont inspirés. Ce ne sont pas les architectures traditionnelles en elles-mêmes qui sont pastichées, ce qui ne serait pas accepté par les bénéficiaires, mais l'esprit qui a conduit à leur production. L'idée de circuit court a fait son chemin, mais elle reste difficile à réaliser. Si consommer un légume issu d'un potager voisin est encore simple, construire une maison issue de son terroir d'implantation demeure complexe. Cette présentation détaillera les stratégies permettant de s'imprégner des intelligences locales pour concevoir des architectures saines rendant hommage au génie de centaines d'artisans qui ont produit des chefs d'œuvre de bon sens, à force de n'avoir pas d'autre choix que de faire avec ce que la nature leur offrait.

Conservation des architectures de terre en contexte archéologique

Sébastien MORISET et David GANDREAU

Résumé

La conservation des architectures en terre, qu'il s'agisse de monuments, de paysages culturels ou de vestiges archéologiques, est un défi. La perte de connaissances sur les matériaux de construction locaux et les changements climatiques rendent la tâche particulièrement délicate. Cependant, le renouveau de l'architecture contemporaine en terre et des valeurs qui lui sont associées ouvre la voie à de nouvelles pratiques plus appropriées pour ces sites. Les pathologies et les processus de dégradation sont désormais mieux compris et leurs effets mieux anticipés. Dans l'ensemble, cependant, les résultats sont encore désastreux : la plupart des sites fouillés sont abandonnés et certaines interventions de conservation accélèrent les dégâts au lieu de les ralentir. Il reste un long chemin à parcourir pour diffuser les bonnes pratiques et faire en sorte que les projets de fouilles intègrent des politiques de conservation appropriées.

Après un rappel du cycle de vie d'un site archéologique en terre, une brève revue des principaux facteurs de dégradation et de leurs effets sera présentée.

La session présentera ensuite l'éventail des options de conservation à la disposition des professionnels du patrimoine responsables de la conservation des biens archéologiques. Les options post-fouilles les plus couramment pratiquées restent l'abandon ou le remblayage, qui peuvent être très efficaces mais qui malheureusement cachent les vestiges. Il existe cependant une autre option, qui consiste à préserver des éléments sélectionnés à l'air libre, dans un contexte de conservation et d'entretien strictement contrôlé et surveillé. Ce type d'approche a bien fonctionné sur plusieurs sites, même s'il n'y a pas de recette miracle. Nous verrons par exemple que les traitements chimiques ne fonctionnent pas à long terme. Il appartient à chaque site de trouver l'équilibre délicat entre les ressources humaines, techniques et financières qui permettront de prolonger la vie d'éléments fragiles qui doivent être exposés au public plutôt que ré-enfouis. Chacune des techniques évoquées sera illustrée par des exemples concrets et nous verrons que ce sont très souvent des approches mixtes qui sont utilisées sur les sites plutôt que des recettes uniques. Les avantages et les inconvénients de chacune des techniques proposées seront également discutés. La présentation de cet éventail de solutions permettra également

d'aborder la question des choix éthiques, de la gouvernance scientifique et des mécanismes d'entretien régulier qui sont essentiels pour la conservation à long terme.

Matériaux terre et constructions en terre : Passé, présent et perspectives

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Résumé

Bien que la terre soit l'un des plus anciens matériaux de construction, elle est plutôt mal connue et son usage est assez peu normalisé. Sa mise en œuvre relève souvent plus de l'artisanat que de la construction standardisée comme c'est le cas pour d'autres matériaux apparus plus tardivement. Cela explique en partie la grande variabilité des performances mécaniques observées autant à l'échelle matériau qu'à l'échelle structure. Par ailleurs, le même matériau peut servir à la construction sous diverses formes selon la culture. De l'Afrique à l'Europe, l'Amérique ou l'Asie, un grand nombre de peuples ont utilisé la terre à une certaine époque. On dispose donc d'un recueil de connaissances sur le bâti en terre, en associant savoir-faire ancestraux et progrès techniques et scientifiques plus récents on peut aujourd'hui en faire une lecture avertie qui permette son optimisation. On s'intéressera ici plus particulièrement au pisé.

Le pisé présente divers intérêts : il est tout d'abord très écologique puisque qu'il ne requiert pas de cuisson et peu de transport car la justification de l'usage de ce matériau est le fait d'utiliser la terre disponible à proximité immédiate. Le bilan carbone est donc très faible, ce qui est un atout majeur de nos jours. De plus, il est abondant dans bien des régions du monde et peut être recyclé sans traitement particulier. C'est également un matériau permettant un confort hygrométrique naturellement régulé.

Toutefois, son usage est limité à cause de plusieurs facteurs : sa faible résistance mécanique en comparaison aux matériaux classiques de construction (béton notamment) et il ne permet pas la réalisation d'ouvrages de hauteur conséquente. On relève tout de même des constructions en R+8 à Shibam, au Yémen. Ce sont les ouvrages en terre crue (adobe) les plus élevés au monde. La vitesse de construction est également un frein à son développement. La mise en œuvre reste très manuelle, artisanale. Aujourd'hui, la tendance est plutôt à l'industrialisation des procédés pour gagner du temps et donc réduire les coûts de main d'œuvre. Notons que le savoir-faire de certaines entreprises spécialisées dans la construction en terre, ainsi que celui

d'architectes reconnus dans ce domaine, permettent aujourd'hui de palier à ces faiblesses et construire en terre devient compétitif, si l'on intègre les nombreux bénéfices induits par ailleurs.

Un certain renouveau est donc bien constaté ces dernières années pour ce matériau avec de nombreux projets, au Maroc, en France et dans d'autres pays. La sollicitation sismique reste cependant un frein notoire, car finalement très peu d'études ont été menées sur ce sujet. Les nombreux effondrements constatés dans le cas de séismes exceptionnels [Iran Bam 2003 (Richter 6.6), Chine Yunnan 2014 (6.1), Maroc Haouz 2023 (6.8)] ne doivent pas induire des conclusions hâtives. L'étude ici menée montre le potentiel de la construction en pisé, ainsi que ses limites face aux séismes. Nous montrons aussi que des dispositions constructives particulières permettent cependant de concevoir des maisons en pisé pouvant résister à des séismes de forte intensité. Il s'agit dès lors, quel que soit le matériau, de construire en intégrant une conception et des dispositions constructives parasismiques, qui permettent d'assurer une protection dans le cas de séismes d'intensité fixée par la réglementation. Le défi des prochaines années est donc bien d'optimiser les bâtiments en pisé en y intégrant ces dispositions afin d'en faire des éléments plus résistants aux séismes.

Pierre de construction dans la région de Gênes (Italie)

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Résumé

La région de Liguria, au nord-ouest de l'Italie, qui en temps historiques s'identifiait avec les domaines de la République de Gênes offre nombre de carrières, exploités en temps historiques, et certaines jusqu'à présent, qui ont fourni une variété de pierres polychrome de construction qui constituent des éléments soit structurels soit décoratifs, de nombreux palais de la région. Aussi comme d'autres carrières ont été utilisées, depuis temps historiques, pour la préparation de la chaux et des mortiers. Dans ce travail on donnera un panorama des carrières principales, aussi qu'une caractérisation des matériaux et nombreux exemples d'utilisation locale.

Les architectures de terre des vallées présahariennes du Maroc : Bilan, résultats et perspectives.

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CERKAS

Point focal national pour la Convention de 1972 de l'UNESCO

Résumé

Dans les vallées présahariennes du Maroc, il existe un grand nombre de sites d'architecture en terre (800 maisons fortifiées/demeures seigneuriales ou *Qasbas/tighermatines* ; 560 greniers collectifs *Igidar/Igherman* et 4000 villages communautaires ou *Qsour/Igherman*). La totalité de ses richesses est tombée en ruine et abandonnée du fait des changements intervenus dans les structures économiques et communautaires qui les sous-tendent, conduisant à leur lente détérioration et finalement à leur effondrement. C'est un problème critique identifié à l'échelle mondiale.

Au Maroc, la signification culturelle de ces établissements est reconnue en raison de leurs valeurs esthétiques, sociales et civilisationnelles et parce qu'ils constituent un témoignage physique du développement historique de la région subsaharienne. Ils sont, pour la plupart, situés dans les vallées du *Dra*, du *Dadès*, du *Todgha*, du *Ziz*, de l'oued Noun et les oasis de *Tata*, de *Figuig*, de *Skoura* et font l'objet d'une protection au titre de réserve de la biosphère. Cependant, l'absence de lien entre la préservation, la régénération de ces établissements et la planification du développement engendre un contexte critique qui met en péril l'existence et la pérennisation de ces sites et pose un véritable défi à relever.

Le déclin de ces zones a eu pour catalyseur la modification profonde des structures de production (principalement agraire) et sociales qui ont poussé la population à migrer vers des agglomérations régionales plus grandes et/ou des villes à l'intérieur ou même à l'extérieur du Maroc, à la recherche de conditions de vie meilleures. L'émigration en masse n'a souvent laissé dans ces sites que les habitants les plus démunis.

Face à cette situation, les Autorités gouvernementales ont entrepris à partir des années soixante du 20^e siècle des actions ponctuelles susceptibles d'atténuer ce processus de dislocation. En général, les interventions restent pour la plupart des cas très difficiles, voire même hasardeuses. Encore aujourd'hui, les architectures en terre qui font partie de notre culture ne cessent de subir l'effet destructeur de la folklorisation et le désintérêt même au cours des opérations techniques. Le malheur c'est qu'il y'a plusieurs acteurs avec un manque flagrant de coordination et le non-respect des compétences et des rôles des organismes qualifiés.

Les moyens matériels et financiers sont devenus assez limités pour de tels travaux de restauration et de réhabilitation surtout des ksour et des Qasbas de la région du sud-est. Les projets nécessitent une vision et une connaissance approfondie de tous les biens monumentaux pour définir les priorités et les interventions d'urgence. Les démarches dans le domaine des architectures en terre suite aux compétences et aux expériences acquises aujourd'hui doivent prendre en considération plusieurs dimensions liées à d'autres champs de recherche notamment l'anthropologie d'autant plus que la clé de développement est essentiellement culturelle et non seulement technique et économique. Le problème de la réhabilitation est plus complexe et ne se limite pas au choix de quelques sites pour réfection ou entretien. L'attention doit être portée aux approches (sociales, politiques, culturelles) et moyens (juridiques, financiers, institutionnels) à mettre en œuvre pour que le patrimoine devienne un levier de l'économie locale au lieu d'interventions assez modestes. En plus, les programmes suggérés (conservation, restauration, réhabilitation, renouvellement, etc.) devraient être conçus selon une stratégie simultanément descendante et ascendante. Elle propose d'appuyer des opérations immédiates indispensables qui génèrent une image positive de ce patrimoine comme espace de vie, et permet de renforcer les connaissances et les compétences des dirigeants, des professionnels et des citoyens pour garantir la réussite, à long terme, de sa préservation. Les projets de conservation territoriale adoptent en général cette approche vu la nécessité de démontrer au plus vite dans un processus qui apparaît inévitablement délicat le potentiel et les bénéfices de la réhabilitation de cette architecture, et ensuite le besoin impératif de s'assurer du soutien de la communauté, d'impliquer des décideurs et responsables locaux dans un large champ d'actions transversales. Pour les institutions gouvernementales, il importe souvent d'agir rapidement pour répondre aux attentes de la population et autres groupes d'intérêt. Toutes ces idées seront traitées, analysées et discutées lors du colloque en vue d'une nouvelle perspective pour les constructions en terre au Maroc suite à l'accumulation des expériences et des recherches en la matière.

Guidelines and Standards for Earth Construction

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Abstract

The practice of earth construction, which involves the use of natural materials like adobe, rammed earth, and other forms of compressed earth blocks, offers an eco-friendly and sustainable approach to building. With its low environmental impact and potential for energy efficiency, earth construction has garnered increasing attention in the quest for green and sustainable architecture. However, despite the growing popularity of earth-based building methods, there is a notable absence of universally recognized standards and codes governing this construction practice.

This study underscores the importance of harmonizing existing standards and developing globally applicable norms for different types of earth construction methods. Such standards are not only essential for promoting responsible and efficient use of earth as a building material but also for ensuring the safety, durability, and sustainability of earth-based structures. By providing a common ground for earth construction practices, these standards have the potential to propel earth construction into the mainstream of sustainable architecture, contributing to a more environmentally conscious and resilient built environment. It provides a comprehensive overview of the significance of codes and standards in the field of earth construction, emphasizing their role in advancing the responsible use of earth as a construction material in an increasingly eco-conscious world.

Keywords: Earth construction; Standards; Adobe; Rammed earth; Compressed earth blocks; Sustainable building.

Oral Presentations

01-061 Mechanical and thermal characterization of local building materials stabilized by gum arabic in the region from the Drâa-Tafilalet region (southeast Morocco).

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Abstract

Morocco enjoys a very remarkable earthen architectural heritage throughout the southeast of the country, earthen constructions which are characterized by its ability to absorb and reject moisture from the indoor air according to the fluctuations of the microclimate of the building guarantees a passive indoor comfort that would save energy. Unfortunately, earthen structures suffer from rapid degradation due to climatic changes (temperature, air humidity, water...). This study concerns mechanical, thermal characterization and durability of compressed earth blocks manufactured (BTC) with clay, gum arabic with different proportions. For this purpose, the mass percentages of 1%, 2%, 3%, 4% and 5% of gum arabic by contribution to the total mass are retained for this research work. cylindrical bricks of BTC are manufactured to carry out mechanical tests, and those of prismatic form are adapted for the determination of thermal conductivities with the method "house high insulation". The use of gum arabic as a binder in construction has given satisfactory results. At a rate of 5% of gum arabic the bricks are associated with a compaction stress of 5.78 MPA for the compressive strength, allow us to obtain BTC with an acceptable mechanical strength and a better resistance to rainwater. In addition, the values of thermal conductivity measured, show that when the rate of gum arabic increases, the thermal conductivity rises. The thermal conductivities of all formulations vary between 0.72 and 1.05 W/(m.K). The durability test carried out on the stabilized and non-stabilized bricks, shows that the specimens not stabilized by gum arabic are totally degraded from 5 min of immersion, On the other hand those stabilized by gum arabic kept their shape more than 5 hours. This study proved the effectiveness of BTC stabilized by gum arabic for use as new sustainable construction materials in the region of Drâa-Tafilalet (southeast of Morocco).

Keywords: Building materials, Clay, Gum Arabic, Stabilization, Mechanical characteristics, Thermal conductivity, Durability

01-038 Physical-chemical and technological characterization of porous ceramics prepared from Moroccan clayey materials

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Abstract

Potential valorization of dark clay-rich materials in the ceramic field has been investigated here. Six clay samples (S1-S6) were collected from Fez-Meknes, Safi, Berrechid and Benslimane cities in Morocco for a classification study and chemical-mineralogical, spectroscopic and thermal characterizations. Chemical analysis showed high amounts of oxides, mainly SiO₂, Al₂O₃, Fe₂O₃, CaO and MgO. Mineralogical evaluation confirmed the presence of clay minerals subordinated by quartz, calcite, dolomite and feldspars as non-clay minerals. Projection of the studied clays samples on the ternary diagrams revealed suitable application for structural clay and brick products. The porous specimens were prepared by uniaxial pressing and sintering to 900, 1000 and 1100 °C for 2 h. The final quality of the prepared ceramic products was evaluated in terms of mineralogical, morphological, technological and mechanical characteristics (i.e., water absorption, bulk density, porosity, linear shrinkage, chemical and flexural resistances).

Keywords: Dark firing clays; Porous ceramics; Sintering; Thermal process; Morphology; Technological properties.

01-002 Restauration architecturale Au-delà de l'incompatibilité physico-chimique des matériaux Problèmes des couleurs et d'esthétique

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Résumé

Cet article traite de l'analyse de la couleur dans le patrimoine bâti et de ses apports aux interventions de restauration. Il particularise la conception du projet de restauration comme un acte interdisciplinaire, mettant l'accent sur une archéologie de la couleur lorsque cela est nécessaire, ainsi qu'une approche esthétique et anthropologique de la couleur, essentielle aux décisions de conception. Le cadre théorique est basé sur la restauration critique de Cesare Brandi et sur l'interprétation culturelle contemporaine, ce qui suppose donc, pour les bâtiments classés ou d'intérêt pour la conservation, des analyses et des interventions au-delà des aspects matériels de l'incompatibilité physico-chimique, étant nécessaire discuter le rôle des couleurs dans les bâtiments restaurés, d'un point de vue théorique, esthétique et phénoménologique. Ainsi, le problème que pose le présent article concerne une sorte d'oubli du fait que les revêtements et leurs couleurs ont pour objectif en architecture, outre leur protection, la communication à travers des solutions esthétiques qui garantissent la lecture des langages architecturaux.

Le contexte conceptuel et méthodologique sera basé sur la théorie de la restauration critique et ses conséquences, en présentant, à travers une recherche qualitative, trois études de cas, se référant aux travaux de restauration architecturale au Brésil. L'objectif sera de discuter les mesures adoptées dans leur dimension symbolique-matérielle, ainsi que leur sens collectif et les problèmes contemporains qui doivent être analysés dans les études chromatiques. Le résultat visé sera de démontrer comment la dimension pratique de la restauration se produit et ses relations avec l'image de la ville, en renforçant que la couleur dans la restauration architecturale n'est pas une question secondaire, mais primordiale, car elle est liée à la forme-composition et la lisibilité du langage architectural.

Mots clés : Restauration, Patrimoine bâti, Couleur, Matériaux, Esthétique

01-003 Characterisation of the materials and construction techniques of Sahrij Labguar: a thousand-year-old abandoned hydraulic structure (Marrakech, Morocco)

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Abstract

Today, Morocco, a country with a semi-arid climate, is facing real water stress, mainly due to global warming. Several strategies have been adopted in the past to manage this essential and vital natural resource. Water is part of the heritage of humankind, and brings together traditional know-how, customary law, rituals and traditional uses. In the past, water was managed as a community, using "khetaras" to channel water from the mountain peaks to the plains, and reservoirs to store and then distribute it fairly.

The Sahrij Labgar basin, a hydraulic structure, like the other structures (basins, khetaras, seguias, etc.), was once part of the water supply system for the inhabitants of the city of Marrakech. They played a central role in ensuring stability and continuous operation, and were the best means of maintaining the balance of water resources and rationalising and optimising their use, both for domestic purposes and for watering crops and plants in a variety of environmental systems and climatic conditions. This reservoir, which dates back to the 12th century, was built by the Almohad dynasty. It is currently abandoned and in a very advanced state of disrepair. From a morphological and functional point of view, this structure is characterised by a quadrangular base and a depth of around 3.80 m, capable of storing more than 40,000 m³ of water. The aboveground part presents a thick masonry with a complex structure realized with the rammed earth technique, often with the addition of lime, while the inner surface is completely plastered.

This basin deserves to be restored to its original function, as were the other Almohad reservoirs in Marrakech. However, in order to carry out an intervention that respects the artefact, it is necessary to know it. This is precisely the purpose of this research, which examines the construction and compositional aspects of the materials used in the construction of the basin.

Keywords: Marrakech, Sahrij Labgar, hydraulic structures, adobe, rammed earth

01-006 Investigating the Influence of Pozzolan and Wood Shavings on the Mechanical Properties of Rammed Earth in traditional building

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Abstract

Latterly, researchers have been trying to invest in clean and sustainable technologies or in the development of new materials with slight environmental footprint to reduce greenhouse gas emissions to lower rates in order to prevent global warming. Among the targeted materials in recent researches is rammed earth, a construction technique using raw earth. This research concerns on stabilizing rammed earth by adding activated natural pozzolan, an abundant resource found in volcanic regions, as well as adding the wood shavings.

The primary aim of this study is to investigate how three variables, namely the percentage of pozzolan, wood shavings, and curing conditions, influence the mechanical properties of rammed earth. The research involved introducing varying proportions of pozzolan into rammed earth material, specifically at percentages of 5%, 10%, 15%, and 20% by weight. Additionally, we used also wood shavings incorporated in rammed earth with same varying proportions. The study depends on these following tests: compression strength, tensile strength, and many physical tests. The addition of pozzolan and wood shaving leads to a substantial improvement in compression and tensile strength. This research endeavors to discover innovative and advanced techniques for the meticulous restoration and conservation of the invaluable historical and traditional building in Morocco.

Keywords: Rammed earth; sustainable construction; pozzolan; wood shavings; mechanical properties; conservation.

01-008 Experimental study of the reinforcement of unstabilized and stabilized local clay materials with date palm fibers

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Abstract

The aim of this study is to experimentally test the stabilization of unexploited clay from the Errachidia region (south-east Morocco) with date palm spathe, with a view to its potential use in construction. The main objective of the present work is to evaluate the thermophysical and mechanical behavior of fiber-stabilized clay blocks. Several samples of spathe-reinforced clay at six different contents (0%, 1%, 2%, 3%, 4%, 5%) were prepared and tested. Thermal characterization was carried out using the House High Insulation method to determine thermal conductivity and resistance. Mechanical performance was measured in terms of compressive and flexural strength. In addition, the chemical identification of Errachidia clay was studied using the X-ray fluorescence method. The results of the clay identification showed that Errachidia clay meets the minimum requirements for the manufacture of compressed earth bricks and adobe. Thermophysical test results showed that the addition of date palm spathes had a positive influence on the lightness and thermophysical properties of clay samples stabilized by spathes. In terms of mechanical test results, the flexural and compressive strengths of clay blocks stabilized with date palm fibers continue to increase up to a fiber content of 3%. After this content, mechanical performance decreases with the addition of spathe and no improvement are detected. Consequently, a fiber content of 3% represents the optimum content for stabilizing Errachidia clay. At this content, stabilized clay blocks show optimal mechanical performance and improved thermal properties compared to reference samples. However,

increasing the percentage of fiber mass leads to an increase in water absorption and a decrease in density. Date palm spathe-reinforced clay compounds can be considered as environmentally-friendly building materials. water absorption and a decrease in density. Clay compounds reinforced with date palm fibers can be considered as environmentally-friendly building materials.

Keywords: Spathe-stabilized clay blocks; Thermal characterization; House High Insulation method; Mechanical performance; Water absorption; Density

01-011 Physico-chemical and mechanical characteristics of traditional Marrakech lime

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Abstract:

Experimental study of the reinforcement To tackle the problem of construction-related pollution, especially the greenhouse effects mainly caused by carbon dioxide emissions, governments have begun to encourage the use of traditional building materials and techniques characterized by their low carbon impact. Among these alternatives is Marrakech lime, produced using traditional processes. Historically, it has been used to produce a special mortar known as Tadrakt, an ancestral Amazigh skill used to waterproof parts in contact with water. In order to identify other ways of adding value to Marrakech lime, a literature search was launched. Physico-chemical and mechanical characterization was also carried out on samples of traditional lime concrete sold on the Moroccan market under the name "Jer de Gram". Morphological and mineralogical analyses were examined using scanning electron microscopy (SEM), energy-dispersive X-ray diffraction (EDS), and X-ray diffraction (XRD). The results showed that the lime examined is slightly hydraulic of varied forms, it is mainly composed of calcite, belite, calcium oxides, silicon, and carbons. Crushing tests show a low compressive strength of traditional lime concrete, not exceeding 1 MPa in the best cases, an unexpected result that contradicts the literature. The reason lies in the sandy nature of the aggregates and the traditional lime production process, which does not allow for effective quality control of the final product.

Keywords: *Marrakech's traditional lime, Lime traditional concrete, physio-chemical characteristics, mineralogy, mechanical characteristics.*

01-012 Experimental characterization of the thermal and mechanical properties of earth bricks stabilized by alkaline solution and reinforced with renewable palm fibers: a comparative study

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Abstract

The use of earth bricks is a sustainable and environmentally friendly alternative to traditional building materials. However, these bricks can be vulnerable to erosion and extreme climatic conditions, which may limit their use in arid and semi-arid regions. In this experimental study, the aim was to improve the thermal and mechanical properties of earth bricks by stabilizing them with a mixture of alkaline solution and reinforcing them with natural fibers (maize, reeds, and olive). To this end, we designed earth bricks with different fiber percentages (from 0% to 8% of soil weight) and a fixed percentage of alkaline solution of 1.5%. After 28 days, the bricks were subjected to an experimental study to assess their thermal and mechanical cleanliness. The results showed that bricks stabilized with a fiber percentage of 2% and 3% had the best mechanical properties. They also showed an increase in thermal resistance as the percentage of fibers used increased. In addition, these bricks had higher compressive and tensile strengths than unstabilized bricks. This experimental study demonstrated that stabilizing earth bricks with a mixture of alkaline solution and fibers significantly improved their thermal properties.

Keywords: *Earth bricks, Natural fibers, Alkaline solution, Thermal properties, Mechanical properties, Building materials.*

01-035 Characterization and Potential Applications of Moroccan Lizardite Clay in Ceramics: Technological evaluation

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Abstract

This study aims to characterize lizardite and investigate the technological properties of ceramics made from this geomaterial through experimental measurements. From the Beni Boussera massif in Rif, Morocco, natural lizardite was taken out and its chemical, physical, mineralogical, and thermal properties were examined.

To identify the mineral phases that were contained in the sample, a purification procedure was used. The results showed that silica (47.16 wt.%) and magnesia (31.21 wt.%) make up the majority of the material. Lizardite and chlorite also make up a larger component of the composition. Uniaxial pressing was used to create ceramic samples, which were then sintered at various temperatures (900, 1000, 1100, and 1200 °C).

Porosity, density, shrinkage, water absorption, mechanical and microstructural properties of ceramics, as well as chemical resistance, were examined and researched with regard to the effect of sintering temperature. A high frequency study of the improved ceramic materials reveals good conductivity of 4.86 E-8 S/cm. The resultant ceramic specimen also has a density of 2.02 g/cm³, 17% porosity, 9.86% water absorption, and a mechanical strength of 19.3 MPa. The end result has been ceramics made from a natural resource with significant technological and mechanical properties.

Keywords: *Lizardite; Magnesian silicates; Ceramic materials; Sintering; Technological properties.*

01-039 Studing of the slag addition and sintering temperature for the technological and mechanical properties of dolomite based porous ceramics

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Abstract

This study primarily focuses on the production of basic porous ceramics using Moroccan dolomite as the primary raw material. Furthermore, it delves into the impact of adding slag on the ultimate product's technological and mechanical characteristics. The initial materials underwent comprehensive characterization, including chemical composition analysis (XRF), mineralogical assessment (XRD), and thermal profiling (DTA-TG).

Subsequently, various ceramic structures were fabricated using the uniaxial pressing and sintering techniques, executed at varying temperatures, reaching up to 1300 °C. The study explored the effects of sintering within the temperature range of 1100–1300 °C on multiple aspects, including morphology, phase composition, technological properties (such as porosity, water absorption, density, and shrinkage), resistance to flexural stress, and chemical resilience. Notably, the optimal sintering temperature was determined to be 1200 °C, resulting in a porosity range of 50.28–41.4%, a density range of 1.7–1.89 g/cm³, a water absorption range of 28.07–24.8%, and a shrinkage range of 1.55–6.25%, which varied based on the quantity of added slag. The experimental findings unequivocally highlighted the beneficial role of slag in enhancing the overall quality of ceramic products, particularly concerning their mechanical properties.

Keywords: *Dolomite; Sintering; Slag; Ceramics; Technological properties*

01-045 Assessing the impact of shale from the Settat Khouribga area on concrete properties

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Abstract

The integration of local materials into the production of reinforced concrete presents a dual opportunity: that of reducing construction costs and environmental impact while promoting economic development in producing regions.

In order to enhance the value of shale from the Settat - Khouribga region and evaluate its impact on concrete, several tests were carried out on this material. Samples were taken and subjected to a detailed characterization, including their mineralogical composition, particle size distribution, and mechanical properties. A comprehensive battery of tests was conducted on the concrete samples, including tests for compressive strength, flexural strength, water absorption, porosity, and resistance to reinforcement corrosion over an extended period. Concrete samples containing clay shale exhibited compressive and flexural strength comparable to, or even greater than, that of conventional concrete samples. Furthermore, porosity and water absorption decreased in concrete samples incorporating clay shale, indicating enhanced durability

Keywords: *Local materials, Reinforced concrete, Clay shale, Durability, Mechanical resistance*

01-049 Étude comparative de l'élimination des effluents liquides par adsorption et par filtration sur membranes à base d'argiles locales

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Résumé :

Dans le cadre de la valorisation d'une argile de la région Drâa-Tafilalet et suite à l'étude de la rétention du phénol qui a été réalisé précédemment par l'adsorption sur une argile nous avons procédé dans ce présent travail à l'élimination du phénol par filtration sur membrane minérale élaborée à base de la même argile. En effet le traitement d'une solution phénolique de concentration connu a été fait par filtration tangentielle à l'aide d'un micro pilote réalisé à l'échelle de laboratoire, la surface filtrante est d'environ 0,0072 m².

Afin de faire une étude comparative de la rétention du phénol par les deux techniques citées précédemment, dans un premier temps la membrane élaborée est caractérisée par plusieurs tests à savoir test de la résistance mécanique, test de la résistance chimique, test de perméation à l'eau et test de la variation de débit en fonction de la pression, dans un deuxième temps les tests de filtration ont été réalisés à température ambiante et à pression de circulation entre 0,5 et 1bar.

Les résultats obtenus ont montré que le procédé de filtration est très efficace à une pression d'ordre de 0,5 bar ainsi la comparaison des résultats obtenu du rendement de l'élimination du phénol par adsorption et par filtration a révélé que la technique d'adsorption peut réduire la concentration du phénol jusqu'à 97% cependant la technique de filtration a enregistré également un pourcentage très important qui est d'ordre de 90%.

Mots clés : argile, membrane céramique, filtration membranaire, adsorption, phénol.

01-051 Amélioration de la résistance mécanique et la porosité des briques élaborées à base d'une argile de la région Drâa-Tafilalet

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Résumé :

Ce travail de recherche porte sur la valorisation d'une argile dans le façonnage des briques de construction. L'argile utilisée dans cette étude a été échantillonnée dans la région Drâa Tafilalet. Dans un premier temps cette matière première a été caractérisée par différentes techniques d'analyses telles que : FX XRD, FTIR, TGA/DTA, ensuite les briques ont été façonnées par voie humide. Afin d'améliorer leurs propriétés nous avons optimisé un certain nombre de paramètres ayant une influence sur la qualité des briques à savoir la taille granulométrique, le volume d'eau ajouté pendant la préparation des pâtes, le temps de vieillissement, le temps de séchage et la température du frittage. La détermination des valeurs optimales a été fait par l'étude de la variation de la porosité, de la résistance mécanique, de la perte de masse et du retrait linéaire en fonction des paramètres précédents. Les résultats obtenus montrent que les briques élaborées présentent des propriétés très importantes.

Mots clés : *brique de construction, argile, résistance mécanique, porosité, pièce céramique*

01-052 L'étude de plan d'expérience dans confection des briques comprimés à base d'une argile et leurs caractérisations

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Résumé :

Afin de répondre aux objectifs de développement durable, les politiques mondiales sont fortement orientées vers la valorisation des matériaux locaux. Dans ce contexte, cette étude propose la mise au point des briques de terre comprimée à base d'une argile. Dans la première partie de ce travail l'argile a été caractérisée par différentes méthodes d'analyse (FX, RX, IR, ATD-ATG). Dans la deuxième partie, différentes formulations ont été élaborées par l'ajout de l'additif organique en proportions non égales. L'objectif principal de ce travail est la conception des briques comprimées de construction offrant une résistance mécanique suffisante et des propriétés thermiques importantes. L'optimisation de certains paramètres tels que la température de frittage, le temps de frittage et le pourcentage de la matière organique a été réalisé par l'utilisation de la méthode de plan d'expérience.

Mots clés : *brique de construction, argile, résistance mécanique, porosité, pièce céramique,*

01-058 Characterization of the physical and thermal properties of raw earth bricks from Ksar Ait Benhaddou

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Abstract

The degradation of earthen architecture in the Drâa-Tafilalet region (Morocco) is a problem that arises with intensity. Indeed, these earthen constructions are confronted with several natural and anthropogenic phenomena which result in their falling into ruins. Our study aims to recycle and valorize the debris from the walls that have fallen into ruin for a possible rehabilitation of this historical heritage.

The debris from Ksar Ait Benhaddou was characterized by different techniques: geotechnical (Atterberg limits, grain size, etc.), physicochemical (DRX, IR, FX, etc.) and microscopic (SEM). Bricks, of standardized dimensions, were made from waste paste mixed with 22% water by mass. They were developed after variable aging periods, mixed or not with stabilizers (portland cement or lime) or with natural plant fibers (straw) (water/solid ratio = 22%)

The effect of the duration of aging and the three adjuvants on the mechanical properties, the thermal conductivity of the material and the formation of hydrates was determined. The studied samples of medium plasticity are made up of non-swelling clays and sand. The compressive strength of the cement-stabilized samples gave the best results. The thermal conductivity of samples stabilized with cement, unlike lime and straw, had an opposite effect.

Key Words: *Raw earth, adjuvants, compressive strength, thermal conductivity, Recycling.*

01-059 Experimental Analysis on Mechanical and Thermal Properties of Wall Mortar Comprising Clay and Reed Fibers from Drâa-Tafilalet Region

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Abstract

In the field of sustainable construction, it is imperative to find environmentally-friendly materials with optimized performance. The present study examines a comprehensive exploration of the untapped potential for using natural resources in the Drâa-Tafilale region, focusing on the incorporation of reed fibers into traditional clay bricks, a naturally abundant and renewable resource. The design of reed fiber-stabilized bricks was carried out using six distinct mixes, mainly differentiated by their reed fiber content, ranging from 0% to 5%. Initial observations highlighted the promising potential of reed fibers. Increasing the reed fiber content in a mix improves the mechanical strength of clay brick compositions (at 1% reed fiber). However, above this threshold, the inclusion of reed fibers led to a decrease in tensile and compressive strength. In addition, the thermal conductivity of the samples decreased with increasing fiber content. Furthermore, brick density decreased with increasing fiber percentage.

Keywords: *Reed fiber; Compressive strength; Tensile splitting strength; Thermal conductivity; clay-based bricks*

01-063 Modeling Heat and Mass Transfer in Walls of Buildings Constructed with Compressed Earth Blocks

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Abstract

Raw earth has been used for millennia as a building material because it provides comfortable thermal conditions for the building envelope. However, it is particularly sensitive to moisture-related issues. Constructing with earth while controlling heat and mass transfer promotes a sound approach to the design and construction of earth buildings.

This study was conducted to numerically model simultaneous heat and mass transfers through certain types of building envelopes constructed with compressed earth blocks. Using the work carried out by several recent studies in this context as a starting point, a mathematical model governing these phenomena was presented, focusing mainly on variations in relative humidity, water content, and temperature. This study was approached using a numerical approach based on the finite element method. The model was implemented using COMSOL-Multiphysics software.

The objective of this study is twofold: on one hand, to anticipate the wall's ability to moderate environmental hygrothermal variations during day and night cycles by considering real scenarios. On the other hand, to describe the saturation state of a wall that has been immersed in water, as well as the effect of this phenomenon on hydrothermal parameters. The simulation results obtained from the numerical model align with the measurements in terms of relative humidity, water content, and temperature. Indeed, to have a simulation tool specifically dedicated to predicting temperature fields, water content, and relative humidity within a building envelope, it is necessary to delve deeper into considering the dynamics of mass transfer phenomena and the impact of heat transfer.

Keywords: *Green building, Earth construction, Mass and Heat transfer, Hygrothermalsimulation, COMSOL.*

01-023 Ancient wall mortars from the mosque of Sijilmassa (Morocco):

Raman and ATR-FTIR characterization

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Abstract

Historical mortars are complex materials composed of binders, aggregates, and additives. Knowledge of their physico-chemical characteristics is of great importance; it permits understanding their evolution through the time and might help to creating substitute mortars with similar properties appropriate while restoring historical buildings.

The present work focuses on structural analyses of mortars from the walls of the mosque of the Sijilmassa city dating back to the VIIIth century, and located in the immediate vicinity of Rissani. Eight mortar samples were collected from the exterior and the interior of the four walls of the mosque. The spectrometric techniques used are Raman and ATR-FTIR.

The results obtained by Raman spectroscopy indicate that the mortars from the interior of the mosque are mainly composed of gypsum, while those from the exterior are composed of calcite and quartz, with the exception of the mortar from the northern exterior wall of the mosque which contains gypsum. The ATR-FTIR measurements are perfectly consistent with those obtained by Raman spectroscopy for the samples from the interior. Regarding samples from the exterior, in addition to calcite and quartz, a strong absorption band associated with clays in the form of kaolinite was also observed.

The obtained results have allowed identifying the raw materials used while preparing these mortars; these are technological indicators useful to manufacture appropriate mortars, from local raw materials or modern ones, while restoring the targeted structures of the Sijilmassa mosque.

Keywords: *Historical site of Sijilmassa; Ancient mortars; Calcite, gypsum and quartz; Raman and ATR-FTIR.*

01-066 Optimization of the building constructed of Confined Stone Walls according to the Moroccan zoning

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Abstract

The Informal construction in Morocco has led to poor-quality, unsafe buildings due to the lack of appropriate building techniques. This is all the more important given the urgent need to offer renovation and construction solutions that comply with regulatory requirements and are adapted to the basic needs of the inhabitants. Stone construction seems to be closely linked to a variety of traditional human activities, and is developing almost exclusively in rural areas, where it is used to improve the living conditions of Morocco's vulnerable populations. The design and construction of confined stone wall structures (MPC) requires careful consideration of the properties of masonry and reinforced concrete materials, as well as the configuration of structural elements, to ensure the safety and durability of the structure. The MPC approach integrates energy efficiency into the design by making the best use of locally available materials, significantly reducing the environmental footprint (short cycle, material recycling, low grey energy), and reducing pressure on local resources as well as CO₂ emissions. The MPC composite wall has a very high thermal inertia and resistance of around 0.62 m² .K/W, which limits heating needs and reduces energy insecurity. This work aims to optimize the MPC building envelope for Morocco's climatic zones and to improve the building's thermal comfort in the absence of a heating/cooling system. MPC construction is known for its high strength, durability, and resistance to natural disasters, particularly earthquakes, and is commonly used in seismically active areas. The thermal insulation properties of MPC structures are also remarkable due to the low thermal conductivity of masonry materials, such as bricks, stones, and blocks, and the ability of thermal mass to absorb and release heat, which can help regulate indoor temperatures. The optimized solutions are calibrated to comply with the Moroccan Thermal Building Regulations (RTCM) and are applicable regardless of the geographical

orientation of the building. The building typology studied is the residential housing type. The dynamic thermal simulations are carried out with the Design-Builder software which was used for the thermal-aerodynamic coupling to take into account the effects of natural ventilation. The envelope of each module has been optimized according to the climatic zones of the RTCM. Thanks to the thermal inertia of the opaque walls, the interior temperature of the module is little affected by daily climatic variations: The interior temperature of the module is maintained during cool nights or summer heat peaks.

Keywords: MPC construction, Comfort, Energy Efficiency, Insulation, Thermal Regulation

01-067 Mortars of mural fragments from al-Qarawiyyin mosque, Volubilis and Banasa sites (Morocco): petrographic and structural analysis

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Abstract

Revealing the mortar recipes and their application technics in architectural heritage is of particular importance from an archaeological background, both to evaluate the technological knowledge of an ancient civilization, and to provide solid basis for the conservation and restoration process. In this frame, our work aims to characterize mortars of mural fragments collected during archaeological excavations in the prestigious al-Qarawiyyin mosque and Volubilis site: two world-renowned in the world heritage list of UNESCO, as well as the historic site of Banasa. The analytical approach is based on petrographic studies on thin sections under polarized-light optical and scanning electron microscopes, as well as complementary structural analyses by Infrared spectroscopy and X-ray diffraction.

The mortars from Al Qarawiyyin Mosque have been characterized as three layers below the pictorial surface: two arriccio layers and an intonaco one. Their analyses revealed respectively gypsum, gypsum/lime and lime binders combined with aggregates, mainly quartz. Furthermore, the SEM images and the elements maps reveal the composition and the morphological aspect of the interface between the lime plaster (intonaco) and the painting layer and indicate the application of the painting paste onto a dry intonaco layer which is consistent with the lime-secco-painting technique. In the case of mortars from Volubilis and Banasa sites, two to three-layer sequences of mortars have been highlighted: arriccio (based on lime and quartz) and intonaco (pure lime). The absence of a boundary between this latter and the pigmented layer, in addition to the non-occurrence of any organic compounds may allude with the fresco technique. On another side, the mortars from the al-Qarawiyyin mosque have shown more homogeneity and a higher binder/aggregate ratio in comparison with those from Volubilis and Banasa.

The obtained results revealed the use of lime mortars in both periods, while Gypsum mortars have been observed only in the Islamic one. Whereas lime mortars are characterized by mechanical resistance and resilience to humid conditions, gypsum ones are known by their adhesive properties and quick setting.

Keywords: *ancient mortars; petrographic and structural analyses; painting techniques; Al-Qarawiyyin mosque, Volubilis and Banasa sites.*

01-068 Comparative analysis of the effect of thermal insulation on the energy requirements of a tertiary building in Meknes

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Abstract

Thermal insulation materials are essential for minimizing heat loss in winter and heat gain in summer in buildings, regardless of the presence or absence of air conditioning systems. Opting wisely, for these insulation materials opens the way to considerable savings in the energy requirements of buildings, while rationalizing the use of air conditioning systems. This is all the more important in Morocco, where the building sector is one of the biggest consumers of energy. As a result, improving the energy efficiency of buildings is an imperative, especially in the current context characterized by the gradual depletion of fossil resources and ever increasing energy costs. Our study focuses on the practical impact of integrating various insulation materials, including phase change materials (PCMs), hemp concrete and polystyrene, into the structure of a tertiary building in Meknes, Morocco. The results of this research highlight that the incorporation of effective thermal insulation in the various construction elements of the building leads to substantial reductions in energy requirements, both in terms of heating and air conditioning. It should be noted that this study was carried out using energy simulations with Binayate and DesignBuilder software.

Keywords: *Thermal insulation; Insulation materials; Energy efficiency; Tertiary building; Binayate software; DesignBuilder software.*

02-009 The transition of Moroccan Riads and Dars into new Socio-Cultural and Sustainable Context

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Abstract:

Some Moroccan institutions have taken essential steps to preserve the traditional Riads and Dars in Fez. However, previous research on the development and rehabilitation of the traditional dwelling only includes interventions on the structural part and thermal characteristics of the traditional habitat and thus ignores the spatial configuration of the house and its transformation according to the practices and needs of today's consumers. Indeed, the newly developed structure and construction technology has not yet been developed and has not been activated in the market. In particular, it is causing a social debate about the authenticity of the traditional dwelling structure.

This research is to deal with the dissolution of the traditional dwelling in the medina of Fez because of the degradation of the construction materials, and the safeguarding and rehabilitation Process of said dwelling. We will particularly tackle the traditional dwelling in terms of prospection of the restoration materials so as to identify the different pathologies that affect these Riads as well as the internal and external factors responsible for each degradation. The main problem would be to answer: How to find the balance between the old and the new to provide a better quality of space?

The defined method will take the form of a systemic comparative approach with case studies of modernization and adaptability carried out in the traditional houses in Morocco.

For the smooth settlement and diffusion of these models of traditional habitat development, we need to derive specific tools and a response strategy for the future Riads technology by understanding the needs of consumers through:

Continuous research on green technology to evaluate the practical performance improvement effect and applicability of activities-oriented design in the traditional house as well as improvement of natural materials in rehabilitation process.

Overall, this research aims to develop a specific scientific approach to transformation and adaptive reuse for sustainable habitability based on classifications of behavioral factors, technical factors and contextual factors in aspects of residential performance and social and cultural transition.

Keywords: Riad, Fez, social-cultural transition, patio, space syntax, space quality, transformation.

02-016 The architectural and literary cultural heritage; a contribution to sustainable development in low density areas of Portugal

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Abstract

Territory and literature are often linked because books describe spaces in the past. Preserving an architectural heritage described by outstanding authors of an era is a very interesting challenge.

Architectural heritage's rehabilitation as cultural heritage can be very important in improving the socio-economic conditions of low-density areas, since the quality of rehabilitation has a significant impact on the urban landscape and consequently on economic activities linked to tourism.

The ability to use traditional techniques to rehabilitate buildings also means preserving knowledge that falls under the intangible cultural heritage; the architectural heritage can also be linked in a very interesting way to the literary heritage, namely through the rehabilitation and preservation of the places mentioned in literary works. The preservation of literary landscapes is an added value for the socio-economic development of places.

In the central region of Portugal, programmes that relate territories with rehabilitated architectural heritage or in the process of being rehabilitated with literary works by authors from the region are being implemented.

This communication presents some cases of architectural and urban rehabilitation in small urban centers, with socioeconomic problems, promoted by their importance in the literary works of Portuguese authors from the 20th century.

Keywords: architectural rehabilitation, cultural heritage, intangible heritage, literature, Portugal

02-017 The Role Of Local Population In Safeguarding Heritage: Case Of Chefchaouen

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Abstract

Local community engagement in heritage conservation has been a growing trend since the 1980s. With international models and charts that introduced the participatory paradigm into public restoration and interventions, a community-based conservation approaches have started to emerge. The involvement of local inhabitants into restoration processes has proven effective contribution into sustaining public interventions and developing behaviors that decrease the rate of deterioration of architectural heritage.

The case of Chefchaouen has demonstrated multiples initiatives taken by inhabitants and local council towards chaouni heritage that is aged from de 15th century and classified historical site. Made of stone, earth, wood and lime, the intervention on the living site has constrained public interventions in restoring it.

Still, the participatory dynamic around safeguarding the historical tissue has contributed to improve public efforts of restoration and rehabilitation. The contribution has gone beyond raising awareness to tangible actions and engagement.

The proposed communication aims to present this case study, which informs about an important aspect of safeguarding patrimonial sites: the input of local population into sustaining heritage. The presentation is based on empiric results and in site investigation with locals.

Keywords: *local initiatives, participation, restoration process, safeguarding heritage, Chefchaouen;*

02-020 Preservation of modern cultural heritage in modern cities – case study of Rabat in Morocco

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Abstract

Building heritage in modern cities is a valuable wealth and an amazing testimony on one's heritage and culture. It allows physical transcription on how a city made it to be what we know and see today.

In Morocco and especially Casablanca, building heritage is also a valuable technical wealth. From an engineering perspective, these constructions were built using materials and techniques that were tested for the first time in Morocco. International architects used several techniques for the first time in Morocco before duplicating in Europe.

Today, this patrimony suffers several structural pathologies including concrete corrosion, structural cracks, capillarity lifts and masonry failure. In this paper, we would like to discuss and study the impact of these pathologies on the building and its stability.

Depending on the depth and the impact of the pathology, a repair program will be presented to address all the issues in a timely manner. The purpose is to present a repair approach that would allow a durable preservation of patrimony all in line with available resources to conduct the required repairs.

The maintenance program needs to take into consideration the causes and sources behind the initial pathologies. Apart from aging, construction material degrades due to lack of maintenance, overuse, non-permitted modifications, poor quality repair material and aggressive environment. The suggested program addresses these items and develops inspection checklists for each area to allow customized maintenance practices.

Keywords: *National Heritage, Inspection, Structural Pathologies, Rehabilitation, Building Maintenance*

02-025 Decaying Moroccan Khettara: Remote architectural assessment of hydraulic heritage in the Draa Tafilalet region

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Abstract

Since water is the source of life, human ingenuity gave birth to undeniably functional solutions through the centuries, to ensure decent quality of life to local populations in the most challenging climatic contexts. But when these climatic factors coupled with hydrologic unfolding scenarios become problematic, some of these structures face serious threats to their continuity.

As a depiction, Moroccan Khettara, commonly called Qanat, as it exists in more than fifty countries suffering from aridity and water scarcity, is in serious decay and is about to reach extinction of the few remaining functional ones. On one hand, this hydraulic heritage dating back to the 12th and 14th century in Morocco, is a completely sustainable method of draining and managing water from underground reservoirs to guarantee irrigation and domestic water availability. On the other hand, it requires a very tricky, dangerous and costly maintenance process, that discourages shareholders who end up abandoning it. Nonetheless, it is a heritage and part of the arid landscape in several regions in Morocco, and requires immediate attention in various fields.

In other countries such as Iran and Pakistan, Qanats are already at the center of attention and are subjects to GIS mapping, inventory process, and experimenting around adequate consolidation conducts and new ideas of repurposing. In Morocco, very few studies are done around the subjects.

The aim of this paper is to contribute to the understanding of the situation of Khettara in Morocco, by setting a preliminary methodology to initiate a mapping process that can be beneficial to help categorize them by potentiality of restoring, conservation or ecotourism, through a remote architectural assessment of a study case in the Draa Tafilalet region, drawing inspiration from aerial archeology and GIS technics, coupled with knowledge around Qanats or Khettara and field work.

Keywords: Khettara, Remote, Hydraulic heritage

02-027 The Rehabilitation Of The Architectural Heritage In The Marinella Agricultural Park

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Abstract

This project examines a large agricultural area located in the plain of the Ameglia Municipality, between two main roads of considerable importance: Viale Litoraneo and Viale XXV Aprile, on the border with Sarzana Municipality in the province of La Spezia, Italy. This area is located one hundred meters far from the coast and belongs to the buffer zone of the Monte Marcello Park, which is characterized by places and landscapes of naturalistic interest, focused on the surrounding elements such as old farmhouses, barns, greenhouses, agricultural plants. All these elements tell the history of human activities related to natural resources and to the sharecropping buildings of the "Fattoria di Marinella", which value is not only historical and environmental but, most of all, it has also a social and cultural meaning. This area of about 75 hectares, entirely cultivated with DOP (protected origin denomination) basil plantations for food destination, hosts abandoned farmhouses that will be restored as one of the project goals. In particular, one of these buildings used as a stable and shelter for agricultural vehicles, will be rethinking order to integrate it in the surroundings, reaffirming the relationship bonds that have been wickered and then lost by the flowing of time. In the past, these relationships shaped the landscape where the human presence had a role of protection for an open territory which has a great environmental and ecological quality, with a rural vocation for carrying out traditional practices and returning to agriculture activities. Once the scope of study, the visual relationships with the surroundings, the analysis of the morphological structure near the coast, the study on different scales has allowed to reveal the organization of built and unbuilt spaces, construction techniques, physical, functional and visual relationships of places on a large scale. The project goal is the refurbishment and expansion of the existing building through the replacement of the large shed while maintaining its shape, orientation and exposure. The project is drawn up with the aim of not decreasing the quality of the places, but, as far as possible, improving them. The choice of materials has been carried out on the basis of technical criteria (fire resistance, thermal insulation and ease of construction) which are extremely important for

the type of activity. The insulating panels, cast on site, will have the same colour of dried soil by means of surface treatment, in order to be integrated into the landscape in contrast to the roof made of dark photovoltaic panels, for energy supplying to the entire processing cycle. This composition has the visual effect of making the building looking lower. The office building will be covered by Terracotta diaphragms, meanwhile the remaining part and the technical rooms, covered by long sheds, will be shielded by bales of straw treated with raw earth and lime. The new production plant is a high-tech system process for the transformation of DOP basil self-produced in surrounding fields for about 80 hectares. The basic aim of the intervention choices is the reuse and recovery not limited to the building but extended to the landscape with the existing crops, which contribute to enrich the environment system and its sensory relationships.

Keywords: *Agricultural Park, Parco agricolo di Marinella*

02-042 Sauvegarde et restauration du patrimoine architectural : Palais Fieschi (Gênes Sestri Ponente). Consolidation structurale de la voute du salon et restauration structurale des elements muraux dans le cadre de la renovation de la couverture

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Abstract

Villa Fieschi, villa du XVIème siècle, abrite aujourd'hui les bureaux de la Municipalité de la Commune de Gênes. Elle est représentative de la technique de construction traditionnelle des toits en ardoise avec une structure porteuse en bois et une voûte en pavillon sous-jacente suspendue en roseaux, plâtrée et peinte dans l'intrados.

La particularité de la toiture est son revêtement en ardoise (abbadini), pierre typique de la Ligurie, et la présence de l'essence de plante *Castanea sativa*. Utilisée pour les éléments en bois de la structure porteuse et pour le bordé. Une autre particularité constructive de l'époque est la réutilisation d'éléments issus de l'art de la navigation, tels que les mâts des navires installés pour constituer la poutre fatière (sapin blanc de la région des Apennins).

A cause de l'âge, des attaques parasitaires et des infiltrations d'eau de pluie au fil du temps, les conditions de dégradation suivantes ont été définies :

- De larges portions d'éléments en bois affectés par les fleurs émergentes des parasites ;
- Pourriture des éléments en bois de la charpente en correspondance avec la traverse et les têtes des poutres principales ;
- Pourriture des têtes des cintres en châtaignier reliés aux nervures de la voûte qu'ils supportent ;
- Effondrement d'une partie de l'enduit peint de la voûte suite à son relâchement une fois déchargé le poids de la toiture ;

La restauration de la structure porteuse et de la voûte peinte est de nature conservatrice, limitant la suppression, le remplacement ou le démontage des éléments.

Une intervention "chirurgicale" a été réalisée au cours de laquelle les parties pourries ont été remplacées par des "prothèses" tout à fait identiques. Pour les éléments les plus fragiles, des tôles de renfort ont été placées à côté.

Les supports de voûte ont été intégrés à de nouveaux, reliés par une selle spéciale aux nervures de voûte dont l'extrados a été replâtré en reconstituant le plâtre tombé.

Des panneaux souples transparents ont été utilisés pour soutenir la voûte et à permettre une inspection visuelle et un contrôle de la fermeture des fissures lors du resserrage des suspentes. Pour atteindre l'objectif susmentionné, il a fallu utiliser de nouveaux matériaux tels que les fibres en verre, les fibres de carbone, les résines époxy, les éléments en acier, le plexiglass : aux matériaux traditionnels s'ajoutent des matériaux modernes qui, comme ils sont parfaitement reconnaissables, définissent un témoignage important des événements technico-évolutifs de l'artefact.

***Mots clés :** Villa Fieschi, Restauration, Matériaux traditionnels, Fibres.*

02-056 La Contribution Du Patrimoine Matériel et Immatériel Tlemcenien Au Développement Local.

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Résumé :

L'attractivité touristique de Tlemcen et sa Médina n'est pas un phénomène nouveau, malgré sa prise de conscience très tardive par les décideurs locaux ou nationaux. Tlemcen comme de nombreuses villes du Grand Maghreb, constituait déjà dans le passé une étape ou une destination dès les premiers déplacements d'agrément, or cet intérêt s'est très atténué au cours des décennies passées. Mais il faut noter que cette attractivité s'est accentuée grâce aux nouvelles pratiques touristiques de ce début du 21^{ème} siècle et le choix de Tlemcen comme capitale de la culture islamique en 2011. Tlemcen est assurément, de toutes les villes musulmanes d'Algérie, celle qui conserve les monuments les plus riches et les plus précieux. Œuvres d'un art exquis, où s'allient le plaisir de l'œil et de l'esprit, la force et la grâce. L'art et l'histoire sont intimement liés, qu'il est impossible de parler du passé sans se référer aux monuments. Ressources identitaires par excellence soutenant une cohésion sociale, développant ainsi une impulsion économique et culturelle durable. Le choix en 2011 de Tlemcen, capitale de la culture islamique, n'a fait que confirmer la richesse de son patrimoine. Plus de 80% de l'art andalou est concentré dans son espace. La mise en valeur de son patrimoine, à cette occasion, place son architecture traditionnelle d'une ville pilote méditerranéenne sur l'orbite d'un classement d'une ville de patrimoine mondial. Cette ancienne capitale des Zianides tient encore, par son dynamisme, à concourir au dialogue culturel régional et interrégional.

L'attractivité de Tlemcen s'explique aussi par son accessibilité. Tlemcen jouit d'une situation privilégiée, mais aussi par sa localisation à proximité des frontières Ouest du pays. Elle est située à cinq heures de route de la capitale, à laquelle elle est reliée par autoroute. Cette proximité de la capitale et des autres villes grâce à un réseau routier dense est à un atout. En

effet, elle favorise la fréquentation des touristes nationaux, qui sont des dizaines de milliers à se rendre chaque année à Tlemcen.

Grâce à un commerce très diversifié et très fleurissant, ayant un ciblage très large, depuis les produits de base jusqu'aux produits de luxe particulièrement la vente des bijoux et la confection des habits de mariées, spécialement la « chadda Tlemcenienne », des dizaines de restaurants et cafés, une vingtaine d'hôtels dominés par les 1 étoile, mais allant jusqu'au 5 étoiles ; l'hôtel Renaissance et l'hôtel Les Zianides. Tlemcen constitue un pôle commercial à ciel ouvert. Cette richesse favorise la venue de la population locale, mais aussi des touristes étrangers.

Malgré cette richesse patrimoniale et les nombreux investissements menés depuis le début des années 2000, qui ont permis à Tlemcen d'être dotée d'infrastructures touristiques modernes et denses, la croissance du nombre de touristes est modeste, mais constante depuis 2005. Les statistiques indiquent que 500.000 personnes ont visité Tlemcen au cours de l'année 2011 sans pour autant préciser si ces personnes sont entrées en Algérie dans le cadre du tourisme ou s'il s'agissait de ressortissants Algériens revenus au pays pour des vacances. A titre d'exemple, la Ville de Marrakech a accueilli en 2013 près de 1.5 millions de passagers contre 900.000 pour la ville de Sousse en Tunisie.

Ainsi, on saisit mieux les processus de Co-développement touristique et patrimonial de la ville de Tlemcen. Néanmoins, l'augmentation de sa fréquentation suppose d'autres composantes, qui permettent de poursuivre la touristification de la Médina de Tlemcen, tout en améliorant sa notoriété sur le plan national et international. Dans ce contexte, l'activité culturelle et événementielle devra s'octroyer un rôle essentiel, comme l'organisation de festivités et d'événements culturels et artistiques.

Mots clés : *Tlemcen, Médina, Patrimoine, Tourisme Culturel.*

02-060 Préservation du patrimoine local et architectural dans la région de l'Istrie slovène contre les inondations côtières

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Abstract

Piran est une ville côtière située dans l'Istrie slovène, sur la mer Adriatique. Elle fait partie du patrimoine local et architectural méditerranéen en raison de son histoire riche et de son emplacement géographique particulier.

Comme dans toutes les villes côtières de cette région, lorsque la mer monte trop, elle peut entraîner des inondations côtières. L'architecture traditionnelle en pierre utilisée à Piran est considérée comme patrimoine local et elle est réputée pour sa durabilité et sa résistance aux intempéries, y compris aux inondations et à l'humidité. Cela s'explique par plusieurs caractéristiques de la pierre utilisée, ainsi que par les techniques de construction traditionnelles employées.

Pour faire face à ces risques et pour préserver l'architecture locale en pierre dans cette ville côtière, y compris dans les Salines, il est indispensable une approche combinée qui intègre la prévention, la protection et la gestion des situations d'urgence. C'est seulement avec un travail continu basé sur la coopération de la communauté locale, des autorités et des amateurs de patrimoine culturel qu'il sera possible maintenir ces bâtiments historiques en bon état pour les générations futures.

Keywords: *patrimoine architectural, Istrie slovène, inondations côtières, construction en pierre sèche, Salines de Piran.*

02-064 Exploration of the Tarda Geosite: Local Materials, Geology, and Cultural Heritage for a Sustainable Future (Errachidia Province, Morocco)

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Abstract

The village of Tarda has a rich cultural heritage linked to construction and the use of local materials. This work aims to put forward a scientific opinion to promote this heritage and enhance its value and protection as part of promoting the Deraa Tafilalet region as a global reference.

This area is characterized by geological formations dating from the Cretaceous period overlying Paleozoic formations. The Cretaceous terrain includes the Aoufous Formation, made up of clays and marls with gypsum passages, and the fossiliferous limestones of the Akrabou Formation. A striking feature of this village is the multitude of traditional kilns used to produce bricks. These kilns, built from the bricks themselves, are small towers with openings at the top and base. Most of these kilns are built in gypsum marl terrain, which is easy to extract.

The traditional brick-making process involves using clay from the clay deposits of the river margins along the Oued Tard. This ancient tradition helps maintain local expertise and contributes to sustainable development by promoting the responsible use of local resources. In addition to their use in construction, traditional bricks are appreciated for their ability to regulate the indoor climate of buildings by providing good thermal insulation. In this way, they contribute to comfortable living in harmony with the oasis landscape, whatever the climatic conditions outside.

Keywords: *Local materials, Cultural heritage, Geoheritage, Sustainable development.*

03-015 Advancing heritage building conservation through HBIM-based VR

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Abstract

The built heritage, identity and history of every civilization require the collaboration of several specialties and a historical database to preserve it and transmit it to future generations. The integration of new technology has successfully addressed the challenges of maintaining and preserving these existing buildings. Historical Building Information Modeling (HBIM) technology, a sub-field of Building Information Modeling (BIM) dealing with the complexity of built heritage, captures, manages, models and documents detailed data. While Virtual Reality (VR) technology offers the features of intuition, realism and collaboration. By combining HBIM and VR, the visualization, analysis, understanding and communication of historical buildings are improved, ensuring an efficient conservation process.

This paper, reviews the capabilities of VR and HBIM technologies, focusing on their impact when combined in heritage conservation practices. The aim is to determine the current state of development of VR technology in the field of existing historical buildings and to identify the challenges and limitations of its application.

Keywords: *Building Information Modeling (BIM), Historical Building Information Modeling (HBIM), Virtual Reality (VR), Built Heritage, Conservation*

03-018 Object Detection Method for Automated Classification of Distress in Rabat's Built Heritage

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Abstract

Rabat, the capital city of Morocco, proudly boasts a rich and complex architectural legacy that beautifully blends historical influences ranging from Islamic to contemporary designs. Conserving this unique heritage holds paramount importance in safeguarding the city's distinctiveness and cultural significance. Conventional approaches to cataloging and categorization have been time-consuming and susceptible to human errors. Hence, this study aims to overcome these obstacles by creating a sophisticated object detection model to streamline the classification process. In this study, we propose a novel object detection method based on deep learning to detect and classify various degradations of built heritage. The dataset used in this study comprises numerous captured images that display diverse types of degradation, including cracks, collapse, rising damp, spalling, delamination, and lichens. Manual annotation was conducted to label the various damages present in the dataset. These labeled images were then used to train and validate the model. Multiple performance metrics were employed to assess and evaluate the model's performance, including precision and recall. Based on the results, the developed model has demonstrated excellent performance in both detecting and classifying different types of damage. The effective application of this model will have extensive implications, including its utility in assisting local authorities with urban planning and heritage preservation efforts, as well as serving as a valuable educational resource and contributing to the promotion of tourism.

Keywords: Built heritage, object detection model, damage classification, automatic detection, deep learning.

03-019 Integrated digital documentation for conservation, the case study of the Torre degli Upezzinghi called Caprona, in Vicopisano (PI) Italy

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Abstract

Located on the Rocky Spur that overlooks the town of Caprona, the Tower of the Upezzinghi is a nineteenth-century reconstruction of the lookout that serves the ancient castle already existing in the mid-eleventh century and destroyed by the Florentines in 1433.

The hill on which it stands has been progressively eroded by the extraction of stone quarries, heavily changing the landscape around Caprona. Until the middle of the last century the rocky spur was still substantially intact and, at the base of the hill, it was possible to identify the remains of the medieval fort. However at the foot of the tower are still visible remains of the medieval tower base. The Tower of Upezzinghi is now in a state of advanced architectural degradation, in addition the extraction of the stone material has been so aggressive that the limit of the quarry has reached about 50 cm from the base of the tower. The small square plan building, is smaller than the one demolished in 1433, because the measurements at the base of the current tower checked a side of about 4.50 meters while the remains of the medieval have a side of about 5.00 meters.

The digital survey was addressed for the preservation of the tower that needs urgent restoration. TLS and UAS instruments were used, with multiple acquisitions that were subsequently compared and calibrated, having as reference data the cloud of Laser scanner points. The maximum misalignment error of the TLS point cloud was within the axial range of 0.015 meters. The restitutions of the elaborated ones have been, seen also the modest dimensions of the building, executed in scale a1:20. The comparison of the mesh model derived from the cloud of laser scanner points and the photogrammetric survey by drone detected errors and misalignments between the two models contained in the 0.05 meters.

Keywords: *Tower of Caprona, digital survey, aerial photogrammetry, documentation,*

03-021 Traditional Architectures Along the Cultural Route of James I of Aragon in the Province of Valencia: Leveraging Laser Scanning and BIM for Heritage Management

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Abstract

This research explores the traditional architectures along the cultural route of James I of Aragon in the province of Valencia, with a particular focus on the implementation of Laser Scanning and Building Information Modeling (BIM) technologies for heritage management. The study centers on a prominent case study, the Almonacid Castle located in the province of Castellon, near Valencia, where a comprehensive 3D model has been constructed using BIM to showcase the castle's evolutionary stages from its Arab origins to its current state. The present work starts and develops from cultural heritage enhancement actions carried out within the project PROMETHEUS - PROtocols for information Models librariEs Tested on HERitage of Upper Kama Sites", funded by the EU Horizon 2020 - R&I - RISE - Research & Innovation Staff Exchange program (Marie Skłodowska-Curie grant agreement No 821870). Prometheus project activities are being conducted by the University of Florence (Italy), the University of Pavia (Italy), the Polytechnic University of Valencia (Spain), and Gdansk University of Technology (Poland), in collaboration with other international corporate partners, with the aim of promoting interdisciplinary action for documenting and structuring information on architectural heritage. The investigation commences by delving into the historical significance of the cultural route of James I of Aragon, unraveling its architectural heritage as a testament to the region's rich cultural past. Through extensive field surveys and archival research, key architectural elements that have withstood the test of time are identified, creating a foundation for subsequent digital documentation. The study introduces the implementation of Laser Scanning technology to capture precise and detailed point cloud data of the Almonacid Castle's physical structure. By employing this advanced technique, the researchers have been able to create a highly accurate 3D representation of the castle, capturing its intricate details and subtle

transformations over the centuries. Subsequently, Building Information Modeling (BIM) is harnessed to consolidate the gathered data and construct a comprehensive digital model. This BIM model serves as a powerful tool for heritage management, enabling a dynamic representation of the castle's various evolutionary phases up to contemporary times. The integration of BIM facilitates a holistic approach to heritage preservation, promoting informed decision-making and efficient planning for restoration and conservation efforts. The research highlights the benefits of adopting laser scanning and BIM technologies in heritage management, specifically in the context of the Almonacid Castle. By digitizing and preserving the architectural evolution of this significant historical site, these technologies play a crucial role in safeguarding cultural heritage and enhancing visitor experiences. Moreover, the study sheds light on the potential for widespread application of laser scanning and BIM in managing and conserving other traditional architectures along the cultural route of James I of Aragon in the province of Valencia and beyond. In conclusion, this research exemplifies the transformative impact of laser scanning and BIM technologies in preserving and interpreting historical architectural treasures. The study advocates for the integration of these advanced tools in heritage management practices, facilitating a more profound understanding and appreciation of the cultural heritage that has shaped the province of Valencia throughout its illustrious history.

Keywords: *Traditional architectures, Cultural route, Laser scanning, BIM (Building Information Modeling), Heritage management*

03-046 Innovation and resilience in the redevelopment, restoration and digitalisation strategies of architectural heritage

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Abstract

The architectural heritage is the expression of the vast cultural heritage, as a set of cultural and landscape assets, of the different national or international territorialities, which indicates in the connective of the heterogeneous urban, rural and mountain landscape areas, an inestimable value of the monumental historical buildings. The various transformative factors of administrative management and socio-economic cultural type, monitored by quality and compatibility indicators, distinguish different realities over time, in which technological innovations prevail. The objectives are the valorisation and resilience of the architectural heritage at different scales, for the reduction of seismic vulnerability and prevention against natural disasters (floods, erosions, seismic risk, exposure to ultraviolet rays, etc.) and climate crisis, through a model operational that focuses on various innovative strategies that also guarantee reuse with a view to sustainability. The intervention criteria on the historical monumental building are according to a project that distinguishes the historical/cultural values with the use of innovative technologies and energy efficiency with the use of innovative materials, for safety needs, fire resistance, integrability, appearance, etc. according to indicators of environmental sustainability and chemical/physical, dimensional, energetic compatibility, etc. with zero environmental impact. Both in line and in cooperation with ICCROM, UNESCO, UNFCCC, Paris Agreement, ICOMOS, New Technology, COP27 Cleantech, etc.

The methodological approach is based on phases of documentary collection, mapping, cognitive analysis, cognitive analysis of the architectural heritage, on a meta-project with verification, monitoring and control of the definitive project. Use of innovative smart non-invasive technologies with properties of durability, flexibility, mechanical resistance, thermal

conductivity, etc. with innovative materials such as fiberglass mesh and reinforcing bars, on the internal surfaces, socks of artificial micro steel strands for the consolidation and linking between the pre-existing and new walls, of pillars, columns, etc. Use of FRP (Fiber Reinforced Polymer) composites in epoxy or polyester resins with carbon fibers, glass, aramid and boron polymers, for reinforced concrete products, etc. 360° video technology, for immersive use both for document management in the archive database and for interactively viewing reconstructed monuments etc., acquisition of 3D models with non-contact 3D scanning technology to preserve and transmit object data in the future. Redevelopment strategies with energy retrofit as part of urban regeneration, sustainable architectural restoration, recovery and consolidation also with a view to new digital reality (DR) and virtual reality (VR) IT strategies. Evaluation systems, analysis of degradation and instability with design, bioclimatic choices, etc. The challenge is to pass on to future generations a sustainable architectural heritage as a document of historical, architectural, artistic, archaeological, etc. value. of cultural heritage.

Keywords: *valorization, architecture, restoration, resilience, sustainability*

04-004 Seismic Vulnerability Assessment of a building aggregate in the historical centre of Florence

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Abstract

Safeguarding the built heritage represents an urgent challenge for the culture and identity of each country. In Italy, past seismic events have highlighted the vulnerability of historic urban centres, as aggregates of historic masonry buildings.

In this work, the vulnerability of the historic centre of Florence, a UNESCO heritage site since 1982, will be investigated in the context of the Vulnerability Index Method, an empirical approach for the vulnerability assessment at the territorial level, proposed by Benedetti and Petrini in 1984, adopted by the Italian Group of Defense from Earthquake in 1994 and integrated by Formisano in 2011 with the key factors linked to the influence of the aggregate layout in the seismic behaviour. In particular, an urban aggregate composed of fourteen masonry in-line buildings (two palaces in the corner and twelve serial intercluded buildings) is considered as a case study. Buildings show a long narrow plan and an inner court and have undergone many transformations throughout history. In-situ surveys, historical and typological analyses, material and constructive investigations, were carried out in order to aid in understanding the mechanical behaviour of these buildings.

The Vulnerability Index Method form has been applied to the case study, making changes and additions in order to consider the specific features and vulnerabilities highlighted in the analysis phase of the aggregate. In particular, two new parameters have been added: the presence of an inner court and incongruous elevation interventions. The scores and weights have been attributed to the new parameters thanks to the results obtained by implementing non-linear FEM models of representative structural unit representative of aggregate buildings. The results of the push-over analysis on the models allowed us to evaluate the influence of the size and position of the court as well as the extension of the elevations on the seismic response.

This investigation strategy is performed to must be replicable and adaptable to other similar contexts. The proposed form turns out to be skilled to identify the specific criticalities of buildings and offers support to find damage mitigation solutions and experiment consolidation interventions.

Keywords: *Aggregate building; masonry; Seismic Vulnerability assessment; Vulnerability Index Method; FEM analysis.*

04-043 Stratégies d'auto(re)construction dans un scénario post-catastrophe.

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Abstract

Cet article vise à mettre en lumière la faisabilité de reconstruire des régions touchées par des catastrophes naturelles à l'aide de procédés d'auto-construction.

Conscient de l'ampleur du séisme qui a frappé le territoire du Maroc le 8 septembre 2023 et de son potentiel destructeur, il est jugé possible d'apporter une contribution en matière de stratégies de reconstruction/réhabilitation des territoires détruits car ces phénomènes sont récurrents, en surtout dans la région méditerranéenne, avec un risque supplémentaire qui vient de la pression humaine dans ces endroits.

On ne peut exclure les travaux réalisés dans le cadre de la réhabilitation des maisons détruites par les incendies au Portugal en 2017, au cours desquels plus de 2000 maisons ont été complètement détruites, une équipe de la Faculté d'Architecture de l'Université de Lisbonne étant chargée de la réhabilitation de 50 maisons.

Simultanément on va réfléchir sur la solution adoptée après la révolution du 25 avril 1974 au Portugal, où une grande campagne a été lancée pour développer le processus de résolution du problème du manque de logement, connue sous le nom d'opérations SAAL (service d'assistance ambulatoire local) qui visait à soutenir la création de l'habitat par l'auto-construction puisque l'État de l'époque n'était pas en mesure de répondre à ce problème par une intervention directe. Des actions de sensibilisation, d'accompagnement direct au projet, d'approvisionnement en matériaux et de contrôle de la construction ont été menées pour s'assurer que les nouvelles habitations répondraient aux conditions d'hygiène, de salubrité et de sécurité.

Troisièmement, il est également important de mentionner le travail réalisé au Portugal dans les années 50 et 60 du XXe siècle, où l'Union nationale des architectes de l'époque (aujourd'hui l'Ordre des architectes portugais) a mené une enquête sur l'architecture régionale au Portugal qui sert encore aujourd'hui de référentiel pour ce qui était considéré comme l'architecture

populaire au Portugal et qui est utilisé de manière récurrente pour interpréter l'image d'une architecture mal informée et essentiellement spontanée.

Dans l'après-catastrophe, il est nécessaire de reconnaître les valeurs qui sont encore sauvegardables, cependant, en l'absence de cette possibilité, la reconstruction doit s'informer à travers la mémoire passée voire à travers des actions pédagogiques, proches des traditions de construction locales afin d'assurer que les populations reconnaissent leur lien avec le patrimoine et en même temps évoquent des tendances de style déjà connues par les habitants mais qui en même temps sont capables d'ajouter quelque chose qui se traduit par une amélioration efficace de la qualité de vie, que ce soit par la sécurité ou la salubrité introduite dans ces zones.

En résumé, cet article est considéré comme opportun car il met en lumière des expériences similaires dans le domaine de la réhabilitation d'émergence et peut contribuer à une autre approche d'un scénario/réalité comme ce qui s'est passé au Maroc, mais souligne également que tous les risques ne sont pas seulement géomorphologiques et peut aussi être climatique/atmosphérique et même hydrologique.

En ce sens, ces trois approches seront utilisées pour aborder une systématisation de ce que pourrait être la méthodologie d'accompagnement ambulatoire locale basée sur la connaissance, la formation, l'information et l'action gouvernementale, ouvrant la voie au développement durable et à une action efficace sur le terrain.

Keywords: *aost-catastrophe; auto-construction; architecture d'émergence; gestion; risque*

04-044 Matériaux locaux et risque sismique.

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Résumé:

Une bonne partie des zones concernées par le séisme d'Al Haouz, sont construites en matériaux terre et pierre ; à ce titre, la terre seule, non renforcée est très sensible aux séismes. Pour y remédier, différentes techniques ont été développées dans le but de renforcer les constructions en terre ; un autre procédé, non conventionnel, au même titre que la terre, plus résilient aux conditions climatiques et risque sismique, il s'agit de la construction en mur de pierres confinées (MPC), qui a été introduit au Maroc par l'Association d'Architectes Solidarité Internationale, avec la construction de plusieurs bâtiments en pierres confinées : un centre social pour femmes dans la région sismique d'Al Hoceima, une école préscolaire à Figuig, un Hammam et bain écologique dans la région du moyen Atlas, et un prototype à Marrakech sur le site de l'AMEE (Green Platform de Agence marocaine de l'efficacité énergétique) ; ce programme vise l'amélioration des conditions de vie des populations locales, notamment en matière de confort thermique; Il s'agit d'une technologie innovante, dérivée du gabion, communément utilisée en génie civil pour réaliser des murs de soutènement, pour l'adapter à la construction de bâtiments habités ou des équipements publics (école rurale, centre de santé, bâtiment administratif) ; les murs porteurs sont fabriqués à partir de cages en grillages confectionnées sur place et remplis de pierres, puis le mur est enduit sur les deux faces afin de protéger le grillage et d'isoler de l'humidité . La composition des enduits s'adapte aux ressources locales et aux besoins en isolation, par exemple terre et chaux.

En outre, la performance parasismique de la technologie MPC a été approuvée par les essais sur table vibrante et sur le terrain. En effet, les agrégats de pierres sont confinés dans des cages en grillage, ainsi le mur ne peut plus se disjoindre ou céder sous l'effet des secousses sismiques. Les cages sont reliées entre elles par des éléments de liaison, formant ainsi une paroi verticale homogène. Le MPC peut absorber et dissiper une énergie très importante sans s'effondrer du fait de la ductilité des fils d'acier et de la liberté relative des agrégats confinés et dispersion de l'énergie sismique.

Mots clés : Séisme, Construction en terre, Isolation, technologie MPC

05-007 Continuity in Change: Vernacular Inspirations for Moroccan Housing of the 1960s and 1970s

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Abstract

The preservation and appreciation of architectural heritage have become increasingly important in the context of rapid urbanization and modernization. This paper explores the enduring value of using local materials and traditional construction techniques in contemporary architecture. Focusing on vernacular architecture of Draa Tafilalet Region, the study examines how references from these historic architectural typologies are repurposed and integrated into new contexts, exemplified through the case of housing projects in Morocco from the 1960s and 1970s.

Vernacular architecture represents a rich repository of local knowledge and cultural identity. It embodies the wisdom of previous generations who developed construction techniques that were in harmony with the environment and available resources. The use of locally-sourced materials such as clay, stone, wood, and thatch enabled buildings to withstand the challenges of climate and geography while reflecting regional aesthetics and traditions.

By delving into housing developments in Morocco during the mid-20th century, the paper reveals how architects and planners such as Elie Azagury, Mourad Ben Mbarek, Faraoui et Demazières incorporated elements from vernacular architecture into their designs. These modern constructions sought to retain a sense of continuity with the past while accommodating contemporary needs and aspirations. Elements like decorative motifs, spatial arrangements, and passive cooling strategies found in traditional architecture were skillfully adapted to create sustainable and culturally relevant housing solutions for the rapidly growing population.

Furthermore, this research investigates how innovative technologies and materials were introduced to enhance the performance and aesthetics of vernacular-inspired housing. By combining old wisdom with new knowledge of the independence, architects achieved buildings that were not only environmentally responsive but also visually striking. These case studies

demonstrate the successful fusion of tradition and innovation, underscoring the significance of maintaining a link with cultural heritage while embracing progress.

In conclusion, this paper highlights the significance of integrating references from vernacular architecture into contemporary design practices, showcasing the potential of using local materials and construction techniques as valuable resources for sustainable and culturally meaningful architecture. By recognizing the timeless wisdom embedded in heritage structures, architects can create innovative, contextually-sensitive spaces that resonate with the past while embracing the future.

Keywords: *insert five key words used Times New Roman font, Architectural heritage, Construction techniques, modern housing, Tradition, Innovation.*

05-010 Traditional earth architecture as a tool for sustainability and adaptation to climate change of heat and cold extremes

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Abstract

The design of sustainable architectural and urban spaces should be one of the essential pillars of any strategy for sustainable development and adaptation to climate change, particularly for the population living in rural areas who suffer from cold during winter and heat during the summer.

This paper focuses on the traditional earth-based materials buildings and tries to see to what extent the building envelope could be improved to achieve and further confirm the objectives: improving thermal comfort and reducing heat loss through the traditional envelope (walls, roof, glazing, low floor). The paper is based on bioclimatic architecture principles and adopts passive energy efficiency in two different climatic contexts, hot and cold. The analysis of the approach method includes three issues: 1) the bioclimatic analysis of the environment/site including the building ambiance; 2) thermal comfort; 3) thermal performance. The methodological tools are based on the bioclimatic analysis of the site and the ambiance for the first two issues; and the prescriptive approach of Moroccan thermal regulation for the third issue.

The built environment constructed with traditional materials, once improved, is able to prove that it is respectful of the environment and without any risk to the user's health. In addition, this traditional architecture confirms the objectives of sustainable development.

Keywords: *bioclimatic architecture, traditional materials, earth, bioclimatic tools, thermal comfort*

05-013 Investigation of the thermomechanical characteristics of compressed earth bricks reinforced with cement and corn straw

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Abstract

The use of compressed earth bricks combined with corn straw in construction offers many advantages. Compressed earth bricks are known for their low thermal conductivity, which means they retain heat well in winter and keep cool in summer, improving the energy efficiency of buildings. In addition, these bricks are lightweight, easy to manufacture locally and therefore sustainable, combining earth, cement and plant fibers such as corn straw, the earth material often cited as the material of the poor, is making a comeback in terms of sustainable construction cost and interior comfort, emerging as a promising option to meet these requirements, they are suitable for many construction applications. The corn-straw mix reinforces the structure while maintaining a certain flexibility, making them resistant to seismic stress. The aim of the work is to evaluate the thermomechanical properties of compressed earth bricks reinforced with cement and corn straw. Compressive strength, thermal conductivity, fire resistance and other relevant characteristics were examined. To achieve this objective, a comprehensive methodology will be developed. In addition, our study involves the determination of the compressive strength and thermal conductivity of cement-stabilized compressed clay blocks on the one hand, and the study of the variation of these properties as a function of corn straw content and 6% cement content on the other. Measurements carried out indicate that the strength of cement-free blocks is 0.64 MPa by the "dry method" for a thermal conductivity of 0.66 W/m.K (determined using the high-insulation house). The incorporation of cement and corn straw leads to a variation in these two properties. First, there is a drop in strength above 0.4% for corn straw. However, the thermal conductivity of blocks with the highest cement content remains close to that of cement-free blocks.

Keywords : *Compressed bricks ; Cement ; Corn straw ; Thermal conductivity ; Compressive strength.*

05-053 L'enduit traditionnel de chaux : un bilan

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Abstract

La restauration et la conservation du patrimoine culturel est devenue une incontournable depuis ce dernier siècle et a été grandement perfectionnée et optimisée au cours de cette période. Pour dépasser les capacités traditionnelles des enduits traditionnels utilisé en nos jours, de nouvelles fonctionnalités et réponses cohérentes sont intégrées, ouvrant le champ des enduits fonctionnels et intelligents.

Les liants et composants efficaces dans la conception des enduits traditionnels de construction peuvent être considérés comme ceux ayant un faible nombre d'additifs, présentant des caractéristiques d'autonettoyage, d'hydrophobie, de perméabilité à la vapeur d'eau et de résistance à l'eau, perméabilité à la vapeur d'eau et durabilité

L'objectif de cet article est de présenter un examen complet de l'état actuel des enduits traditionnels fonctionnels et intelligents produits par ajouts de nouveau composants, la variation des pourcentages des éléments constitutifs ou l'analyse approfondie des enduits existants. Il décrira dans un premier temps les différentes technologies et additifs, en mettant l'accent sur la manière dont différentes techniques obtiennent de nouvelles caractéristiques requises pour former un enduit. Il se concentrera également sur l'environnement auquel les particules de matières premières sont exposées en termes de température et de vitesse ; une discussion suivra sur les fondamentaux sur lesquels les enduits sont conçus et l'efficacité de leurs performances ; Enfin, les applications réussies, actuelles et potentielles, seront décrites. La flexibilité de conception inhérente aux enduits traditionnels fonctionnels et intelligents a été exploitée pour explorer de nouvelles possibilités passionnantes dans de nombreux domaines différents. Certaines applications incluent, sans toutefois s'y limiter, la prévention de la contamination bactérienne et des infections dans les environnements hygiéniques. Tous ces développements passionnants ouvrent la voie à de nombreuses applications à venir au cours de

la prochaine décennie, faisant du domaine des enduits traditionnels une opportunité unique pour la recherche et le développement

Keywords: *restauration, enduits traditionnels, conservation, développements, fonctionnels.*

05-028 Phosphate mine tailings-based geopolymer composite: Mechanical and thermal behavior

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Abstract:

Geopolymer composites are materials made from aluminosilicate minerals and a binding agent. These composites offer several advantages such as being eco-friendly, fire-resistant, and having improved mechanical properties compared to traditional building materials. The main purpose of the present research is to develop a new eco-friendly composite geopolymer based on metakaolin substituted by phosphate sludge (PS) and reinforced with glass fibers. The mechanical and microstructural characteristics were investigated through characterization by XRD, SEM and bending strength tests both prior to and after heat treatment. The findings revealed that the addition of glass fibers significantly improved the mechanical properties as well as after heat treatment and this was positively correlated with the microstructural transformation above 600°C represented by crystallization. Therefore, PS-based geopolymer composites offer an ecological material suitable for a wide range of potential applications.

Keywords: *Phosphate sludge, geopolymers composite, thermal behavior, microstructure*

05- 031 Enhancing Geopolymer Properties Through Natural Phosphate Additives : Characterization And Performance Evaluation

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Abstract

The aim of this research is to investigate the effect of natural phosphate on the geopolymer characteristics. In this study, Natural phosphate was used as an additive for the partial replacement of metakaolin with an amount ranged between 2 to 20% by weight for geopolymer preparation activated with an alkaline solution composed of sodium silicate a sodium hydroxide. Different analysis methods have been applied for characterization of the raw materials and the developed geopolymers, such as laser particle size, compressive strength, x-ray diffraction, FTIR and scanning electron microscopy SEM. The results showed that the elaborated geopolymer present a compressive strength ranged between 35 and 56 MPa with an increase of (12% by weight of PN), above this quantity (14% by weight of PN) negatively affect the compressive strength (26 MPa). XRD and FTIR and SEM analyzes revealed that the unreacted particles or partially reacted do not well connected to the matrix, and also that the geopolymer samples containing 16% by weight of NP had a higher amount of unreacted particles and the matrix appeared to be denser than that of the reference geopolymer. However, the use of natural phosphate with a structure similar to that of fluoroapatite (Ca₁₀(PO₄)₆F₂) has led to a significant improvement of physical properties and contributes to the geopolymer structure densification.

Keywords: *Eco-friendly materials, geopolymers, locale resources, natural phosphate, mechanical properties.*

05-032 Sustainable Geopolymer from Ceramic Industry Wastewater Sludge: Mechanical, Thermal, and Chemical Performance Evaluation.

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Abstract:

Geopolymers are a new type of material on the borderline between ceramic materials and cement and glass. They are inorganic polymeric materials manufactured by activating an aluminosilicate resource with an alkaline solution consisting mainly of an alkali metal hydroxide (Na⁺, K⁺)[4], with setting and curing temperatures close to room temperature (25-80°C). Geopolymers have attracted a great deal of attention in recent years thanks to their chemical properties, good thermal behavior and good compressive strength. In addition, the sanitaryware industry generates various types of liquid and solid waste, such as washing water sludge. These sludges create enormous ecological problems in Morocco and throughout the world, which means that they need to be reused more profitably and in a more environmentally friendly way. The aim of this study is to create a new metakaolin-based geopolymer for valorizing wastewater sludge from the sanitaryware industry. The experimental process consists in replacing metakaolin with calcined and non-calcined sludge at different percentages as a source of aluminosilicate, in order to study the mechanical, thermal and chemical performance of this new geopolymer composite. Preliminary results have shown that the addition of a percentage of washing sludge ranging from 10% to 90% can increase compressive strength by up to 45 MPa. The next step in this work is to study the resistance of the composites developed to aggressive environments such as acidic, basic and marine environments. In the light of these results, we can deduce that composite geopolymers based on washing sludge can valorize the wastes of a large part of the ceramic industries and reduce their impact on the environment by using them as substituents to metakaolin in the manufacture of geopolymers.

Keywords: geopolymer; industry waste; ceramic sanitary sludge; mechanical properties.

05-034 Effect of decarbonated natural graphite additions on metakaolin based geopolymers: A mechanical and microstructural Study

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Abstract

The aim of this study is to determine the effect of decarbonated natural graphite addition on the mechanical and microstructural properties of alkali geopolymers with different concentration of the reinforcement from 10% to 70%. Herein, we studied the impact of the size particle and the decarbonation conditions of natural graphite on the properties of geopolymer composites. It was shown that the presence of carbonate minerals in natural graphite's composition have a profound impact on the consolidation of geopolymer composite paste. Moreover, the mechanical characterization of geopolymer composite showed a high compressive strength for a 50% of decarbonated natural graphite and that result was influenced by the dispersion of graphite in geopolymer matrix noticed by SEM analysis.

Keywords: Graphite ore; Decarbonation; Thermal resistance; Geopolymer; Compressive Strength

05-047 Feasibility and physico-mechanical characterisation of *eco-friendly* cellular concrete-based flax by-products

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Abstract

The reduction of energy consumption in construction, production of thermal insulation materials, and the solution of environmental problems by recycling by-product derived several industrial sectors are becoming greater problems. In this context, vegetable by-products are considered as an excellent alternative material to substitute mineral aggregates because they are easily available and renewable low-cost raw materials, and have higher advantage for economy and environment concerns.

The viability of using vegetable materials such as flax particles for developing a sustainable Lightweight Cellular Construction Material (LCCM) has been investigated in this paper. The material produced containing different volumes of flax particles (0V (control specimen), 1V, and 2V) was lightened by creating a porous structure in the matrix through a chemical reaction between Aluminum powder and free lime derived from the binder material.

A study conducted on hardened material properties has indicated a significant reduction in sample unit weight, thereby resulting in a level of compressive strength compatible with a load-bearing wall. The reduction in flexural strength was lower than that in compressive strength. This study has also highlighted the effect of the porous structure on the thermal conductivity that lead to provide a high degree of thermal insulation. These results show that the cellular material based on flax particle can be used as suitable insulated load-bearing walls.

Keywords: *Flax by-products, Sustainable materials, Cellular concrete, Porous structure, Physico-mechanical properties.*

Poster Presentations

01-026 Raman spectroscopy characterization of stone flooring “calçada marble”, in Lisbon, Portugal

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Abstract

The Lisbon "Calçada" sidewalks have a traditional style made of small flat and irregular cobblestones, representing magnificent mosaics. This work presents the characterization and identification of the mineralogical phases of sidewalk stones, originating from Lisbon, Portugal. Samples referenced MEKPBL (white) and MEKPNL (grey-black) were studied by Raman spectroscopy. All Raman spectra show a strong band around 1089 cm⁻¹ which can be attributed to the ν_1 symmetric stretching mode of (CO₃)²⁻, indicating that calcite (CaCO₃) is the main crystal phase in both samples [1]. All Raman spectra of MEKPNL show also graphite fingerprints localized around 1329 cm⁻¹ and 1607 cm⁻¹, which are characteristic respectively of the D and G peaks of the carbonaceous material [2]. These carbonaceous materials are the substance responsible of the grey-black color to these stones [4]. Furthermore, the Raman spectra of the MEKPNL sample show also a weak Raman band located at 460 cm⁻¹ which can be attributed to the symmetrical stretching of Si-O-Si, characteristic of the α -quartz phase [3]. All these results obtained by Raman spectroscopy are followed by XRD and XRF analyses which are in interpretation in order to achieve a complete characterization.

Keywords: *Raman spectroscopy, Characterization, Mineralogical phase, Calçada.*

01-048 Étude expérimentale et théorique utilisant la méthode DFT pour l'adsorption compétitive de deux colorants cationiques sur une argile de la région Drâa-Tafilalet

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Résumé:

Ce travail vise la valorisation des matériaux locaux de la région Drâa-Tafilalet dans le traitement des effluents liquides. Dans ce cadre, l'adsorption de deux colorants cationiques qui sont : le Vert de malachite (VM) et le Méthylène Blue (MB) sur une argile originale de cette même région Drâa-Tafilalet a été étudiée dans un système simple et binaire. Certains paramètres expérimentaux, tels que la quantité d'adsorbant, le temps de contact, la concentration de la solution, le rythme d'agitation et l'effet de la température, ont été étudiés. L'étude cinétique révèle que l'adsorption suit le modèle pseudo-second ordre ainsi que le model de Freundlich. Les résultats de l'étude thermodynamique suggèrent que le processus d'adsorption est endothermique et spontané. Pour mieux comprendre le processus d'adsorption, nous avons effectué une étude théorique en se basant sur la méthode de densité fonctionnelle. La comparaison des images MEB avant et après adsorption nous a permis de voir la répartition de colorant à la surface. L'analyse EDX montre un accroissement de pourcentage de carbone. Ce dernier qui a été de 7% avant l'adsorption passe à 19% après adsorption, cette augmentation est due à la fixation de colorant organique sur la surface de l'argile étudiée.

Mots clés : *argile, la méthode DFT, eaux usée, adsorption, colorant cationique.*

01-050 Études cinétique, thermodynamique, mécanisme d'élimination du vert de malachite en solution aqueuse par les argiles brutes de la région Drâa-Tafilalet

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Résumé :

L'objectif de ce travail est l'étude de l'élimination du Vert de malachite en milieu aqueux par l'adsorption sur deux argiles (ABT) et (ABE) de la région Daraa-Tafilalet. Les deux adsorbants ont été caractérisés par plusieurs techniques d'analyses à savoir la fluorescence-X, infrarouge à transformée de Fourier (IRTF), diffraction des rayons (DRX), analyse thermogravimétrique (ATG), analyse thermique différentielle (ATD), (BET) et pH_{PZC} . Les essais d'adsorption du Vert de malachite ont montré que l'équilibre a été atteint après 40 minutes d'agitation pour les adsorbants à différentes températures (25, 35 et 45°C) avec un rendement maximal d'adsorption égale à 88,5 mg. g⁻¹ pour ABT et 89,6 mg. g⁻¹ pour ABE. La modélisation non linéaire indique que les cinétiques d'adsorption sont décrites par le modèle de pseudo second ordre, tandis que les isothermes d'adsorption correspondantes suivent le modèle de Freundlich. L'étude thermodynamique montre que l'adsorption du vert de malachite est endothermique. La comparaison des images de la microscopie électronique à balayage avant et après adsorption confirme que le vert de malachite a été adsorbé.

Mots clés : *Adsorption, Vert de malachite, Isotherme, cinétique, Mécanisme.*

01-062 Thermophysical properties of rammed earth incorporating Drinking Water Treatment Sludge

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Abstract

The process of purifying water generates a significant amount of sludge from treating drinking water, which can lead to an ecological imbalance when it accumulates in the environment. Currently, about 73% of treated sludge is repurposed for agricultural use, where it can be transformed into compost or fertilizer for land application. The decision to repurpose the sludge into compost is generally made by local authorities. One potential approach for recycling this sludge involves partially replacing sand with it in rammed earth. While previous studies have investigated the mechanical properties of rammed earth mixtures that contain drinking water treatment sludge (DWTS), this study is novel in its exploration of the sludge's thermophysical properties, such as its thermal conductivity and thermal diffusivity. To conduct the study, a group of five rammed earth mixtures was prepared, with sand substitution levels ranging from 0% to 20%. Various tests were conducted to assess the mixtures' workability, porosity, density, and thermal properties. The results of these tests indicated a decrease in workability, density, and thermal conductivity, as well as an increase in porosity. Thus, the study demonstrated that replacing sand with DWTS in rammed earth leads to an improvement in thermal properties, relative to conventional mixtures, and suggests that DWTS can effectively replace sand in rammed earth. In addition to its advantages for the construction industry as a source of raw materials, the utilization of DWTS for rammed earth provides an eco-friendly solution for disposing of DWTS and preserving natural aggregate reservoirs.

Keywords: *Drinking Water Treatment Sludge, Eco-friendly mortar, Thermophysical properties, Materials Recycling, Energy efficiency.*

01-057 Thermal characterization of a new bio-composite building material based on gypsum and date palm fiber

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Abstract

The building materials used in Morocco are characterized by low thermal resistance, resulting in considerable expenditure in terms of energy consumption. The promotion of new sustainable construction and insulation materials is becoming a necessity. The aim of this study is to develop the thermal properties of plaster by mixing it with date palm fiber (DPF) for use as an exterior wall coating. To determine the thermal properties of the Gypsum-DPF bio-composite material, several experimental measurements of thermo-physical properties were carried out to determine bulk density, thermal conductivity using the steady-state hot plate method. The results showed that the addition of date palm fiber led to a remarkable reduction in bulk density of around 17.16%, while thermal conductivity was reduced by around 26.24%, demonstrating the value of using this bio-composite material in building construction to ensure thermal comfort and reduce greenhouse gas (CO₂) emissions.

Keywords: *Building materials; Gypsum-DPF, Hot plate method, Bulk density, Thermal conductivity.*

03-055 Preserving Historical Medinas: Exploring preservation through Bim scanning and Augmented Reality

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Abstract

Historical medinas, emblematic of architectural heritage and cultural significance, face an intricate challenge at the nexus of tradition and innovation. This article explores the multifaceted dimensions of preserving these ancient urban centers in an era marked by rapid urbanization and technological advancement.

In response, this research advocates for a multidisciplinary approach to preservation, integrating traditional conservation methodologies with technologies. Building Information Modeling (BIM) and augmented reality are examined as transformative tools for precise structural documentation and efficient restoration planning.

Through comprehensive analysis and case studies, this article provides valuable insights for urban planners, conservationists, and policymakers. By reconciling the rich historical medinas with the demands of contemporary urban development, this research contributes to the discourse on sustainable heritage preservation, ensuring the continuity of these cultural treasures into the future.

Keywords: *Historical medinas, building information modeling BIM, architectural heritage, augmented reality, preservation*

03-001 Conservation-intervention methodology of Historic sites through the analysis and mapping of building materials

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Abstract

Among the most recent actions regarding the protection and enhancement of cultural heritage are those taken as a result of the COVID-19 sanitary emergency. In particular, some of these interventions include the creation of the Fund for Culture and the Fund for the Restoration and Conservation of buildings of historical and artistic interest. Moroccan cities constitute an enormous collection of historic centers. Many historical coherences are accompanied by diverse construction methods, a variety of materials, and execution techniques specific to local traditions, as well as diversified composite and aggregate systems. This requires reflection not only on the singularities discovered each time but also on a general methodology that allows for the proper recognition and evaluation of cultural value and the identification of coherent methods of conservation and intervention. In this regard, this paper describes the scientific initiative aimed at developing a conservation methodology that proposes adequate interventions for the artifacts of the archaeological site Chellah (Rabat, Morocco). To achieve this, the historic buildings on the site have been analyzed, with studies exploring the potential of traditional materials and construction methods used. The historical knowledge of the site is organized into a structured whole through traditional and technological surveys and cognitive investigations. The data set is collected in a digital information management system (GIS) to develop thematic maps that include both qualitative and quantitative data. Furthermore, this approach can facilitate the planning and implementation of compatible conservation interventions.

Keywords: *Cultural heritage; building conservation; preventive intervention; thematic maps; restoration*

04-041 Tire-Based Anti-Seismic Fibers to Increase the Ductility of Traditional Hydraulic Lime Concrete

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Abstract:

Fibers have been widely used in construction since antiquity to reinforce raw earth or lime-based mortar. They prevent the propagation of micro-cracks and improve cohesion and shear strength. High-elasticity and plasticity fibers also enhance the material's capacity to absorb energy. The aim of this paper is to investigate the possibility of improving the seismic behavior of traditional buildings through the incorporation of fibers extracted from waste tires known for their high ductility. The objective is to recycle this non-biodegradable waste and utilize its mechanical characteristics to enhance the seismic performance of traditional buildings. Rubber fibers were incorporated at a rate of 1.5% and 3% on a comparative traditional hydraulic lime concrete. Ductility parameters are estimated from the analysis of stress-strain diagrams obtained by applying uniaxial compression tests in accordance with French standards NF P94-420, and NF P94-425. The results show a significant improvement in the traditional hydraulic lime concrete ductility after the addition of fibers made from tire waste. This method will enable the recycling of tire waste, environmental protection, and enhanced seismic performance of traditional structures. The aspects to be addressed for the development of research fields on earthquake-resistant fiber technology were also formulated.

Keywords: *Earthquake-resistant fibers, traditional lime concrete, tire recycling, rubber, ductility.*

05-054 The architectural authenticity of the Tafilalet region: preservation of traditional construction techniques and valorization of local materials

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Abstract

The Tafilalet region, located in the southeast of Morocco, has a rich architectural heritage that embodies the history, culture and identity of the local community. This article aims to examine the preservation of the architectural authenticity of Tafilalet by focusing on the conservation of traditional construction techniques and the valorization of local materials. For this objective, an in-depth documentary research was carried out, analyzing historical archives, testimonies from the local community and previous studies on the subject. We also conducted interviews with heritage preservation experts and local artisans, collecting crucial qualitative data. Finally, field visits were carried out to directly observe traditional buildings, their construction techniques and materials. The Tafilalet region has exceptional architectural wealth, characterized by the use of local materials such as raw earth, stone and date palm. However, this authenticity is threatened by factors such as rapid urbanization, modernization of construction materials and the loss of traditional skills. Local communities are aware of the importance of preservation, but they need support to implement appropriate restoration methods and promote the use of local materials in contemporary construction. Preserving the architectural authenticity of the Tafilalet region is a crucial issue for preserving the cultural identity and heritage of the region. This study highlights the need for concerted action, involving local authorities, preservation experts, local communities and development actors. It is imperative to develop training and awareness programs and promote the use of local materials in modern construction to ensure the sustainability of these unique architectural treasures.

Keywords : *preservation ,local materials, valorization, authenticity, traditional construction techniques*

05-065 Sustainable Composite Mortars for Architectural Heritage: Thermal and Mechanical Properties with Natural Pozzolan and Fly Ash

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Abstract

Cement, a widely used construction material, is responsible for a substantial 6-8% of global CO₂ emissions. Finding ways to mitigate its carbon footprint while maintaining cost-efficiency is a formidable challenge. Extensive research efforts have explored the substitution of cement, in part or entirely, with alternative materials. Simultaneously, there has been a growing recognition of the pivotal role of superior thermal insulation in buildings to optimize energy conservation. This has led to increased attention towards thermal insulation in architectural and construction practices.

This study presents experimental findings on the thermal and mechanical properties of mortars formulated with natural Moroccan pozzolan and fly ash. Natural pozzolan, an abundant volcanic material, is available in substantial quantities, in contrast to cement, which necessitates energy-intensive extraction. Fly ash, an industrial byproduct of coal combustion in thermal power plants, can be effectively employed as a partial substitute for cement powder. The primary objectives of this research encompass diminishing cement consumption, valorizing industrial waste, and harnessing local, underutilized resources to reduce environmental pollution.

Ten distinct mortar mixtures were developed, featuring varying proportions of natural pozzolan (ranging from 0% to 40%) while maintaining a consistent 10% inclusion of fly ash as a cement replacement. The cured mortar samples underwent testing for compression strength, thermal conductivity, and thermal heat capacity using a TPS1500 hot disc analyzer after 7 and 28 days of curing.

The results of these tests underscore the potential of utilizing fly ash and natural pozzolan not only for structural applications but also for their significant thermal insulation properties. The obtained mortar compositions exhibit lower thermal conductivity values and higher specific heat capacity, attributes highly advantageous in architectural and heritage preservation where local materials play a crucial role in sustainable construction practices.

Keywords: *Natural pozzolan, fly ash, sustainable materials, cement, volcanic ash.*

05-061 Effect Of Pressure On Structural And Mechanical Behaviors Of Zirconium Monoatomic Metallic Glass

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Abstract

In this study, molecular dynamics simulations used with embedded-atom potential (EAM) to investigate structural and mechanical behaviors of zirconium Zr pure metallic glass. Properties structural examined by analyzing the radial distribution function (RDF), Voronoi tessellation and coordination number. Besides, tensile loading mechanical investigated by calculating some parameters such as young's modulus E, Yield strength and tensile strength. The simulation results confirm that the splitting in the second peak of the radial distribution function (RDF) proving the formation of amorphous phase for cooling rate 10^{13} K/s under different pressures from 0GPa to 40 GPa, and the glass transition temperature T_g increases with rising pressure. The Voronoi tessellation indicated that the percentage of crystal-like, mixed-like and icosahedral-like clusters change with pressures. besides, the coordination number is specified that a pressures increases during the cooling process, the local environment and topological structure of zirconium metallic glass change. For mechanical properties, the Young's modulus E is very important at high pressures, such as E equals 32,34GPa, 35,53GPa, 35,08GPa, 36,74GPa and 33,9GPa for 0GPa, 10GPa, 20GPa, 30GPa and 40GPa respectively.

Keywords: *Zirconium metallic glass, radial distribution function, Voronoi tessellation, coordination number, young's modulus*

05-022 Characterization of the mortars of the bases and pillars of the ancient city of Sijilmassa (Morocco): elemental and structural analyzes

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Abstract

The present work consists in an experimental investigation of the mortars used in bases and pillars structures of the mosque of the historic Sijilmassa city. A set of five mortar samples, three from the bases and two from the pillars, have been collected with aim to analyze their crystalline and elemental compositions by means of X-ray diffraction (XRD) and X-ray fluorescence (XRF) techniques.

(XRD) revealed that the mortars of the first and the second bases as well as the mortar of jointing between the stone bricks of the pillars are mainly based on gypsum, while those of the third base and the jointing between the terracotta bricks are based on calcite and quartz. These results are in agreement with those deduced from XRF analyses, indicating significant levels of calcium (>20%) and sulfur (>16%) in the first and second bases mortars, as well as in the mortar joining the stone bricks, confirming thus the presence of gypsum. Additionally, a high calcium content (>19%) and a low average silicon content (>11%) were found in the mortars sampled on the third base and on the joint between the terracotta bricks, confirming the presence of calcite and quartz. Other elements (Al, Mg, Fe, K, Na, Ti, P, Mn, Cl, Sr,...) were also identified in all mortar samples with relatively low levels.

The experimental results obtained will be deepened and completed by other investigations in view to go back to the ancient techniques used by the artisans of the period.

Keywords: *Historical site of Sijilmassa; Mortars of bases and pillars; Calcite, gypsum and quartz; XRD and XRF.*

05-029 Characterization of Materials and Formulation of Optimal Concrete Mixtures: A Methodological Approach.

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Abstract:

In this article, we present an in-depth study aimed at characterizing the materials used in the production of various concrete compositions. Our main goal is to understand the properties of the constituent aggregates of concrete, with an emphasis on size, shape, density, porosity, and crush resistance. This comprehensive characterization of materials is crucial for the formulation of optimized concrete mixtures.

We provide a detailed description of the mixture composition methodology, explaining how we adjust the proportions of different constituent materials using the aggregate characterization data. These mixtures are then subjected to compression strength tests to assess their performance and determine their suitability for specific applications.

Our results highlight the importance of material characterization in the concrete mixture formulation process. The data obtained allows for the selection of the most suitable formulations to meet the requirements of various applications. This methodological approach contributes to improving the quality and durability of concrete structures in various construction fields.

Keywords: *Concrete; Cement replacement; Sustainability; Non-load bearing concrete; Durability of concrete structures.*

05-030 Un-Calcined Phosphate Sludge-Based Geopolymer Materials: Thermal Stability, Mechanical and Microstructural Properties

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Abstract

With the development of mining industries, it is critical to safely valorize mining waste. Past approaches to this issue have included calcination and higher alkalinity to improve the reactivity of geopolymer-based matrices; however, the materials developed are not yet industrialized on a large scale.

In this work, thermal stability, microstructure, and mechanical properties of geopolymer concrete incorporating uncalcined-phosphate sludge (UPS) were investigated. This process allows the recycling of a large amount of UPS without heat treatment as a partial replacement of metakaolin (50 wt.%), within the concept of the circular economy, which is the main objective of mining industries. The effect of metal alkali type on the compressive strength values, visual inspections, weight and elevated-temperature exposure of the matrices were determined in this investigation. It is concluded that geopolymer produce develop acceptable mechanical strength and demonstrate high thermal stability. No deterioration occurred on the surfaces of the matrices exposed to the thermal treatment (500°C), whereas the samples exposed to the heat treatment (800°C) suffered weight loss and a drop in compressive strength. The outcomes are very promising and indicate that UPS from Moroccan phosphate mines could be valorized for the production of geopolymers materials that would be used as precast coating materials with excellent performance and low carbon footprint.

Keywords: Geopolymers, Mine waste valorization, Thermal stability, Circular economy

05-033 Experimental study on carbonation resistance of concrete of mixture used for construction in Morocco

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Abstract

Many reinforced concrete structures in Morocco often experience premature deterioration due to carbonation-induced corrosion of their reinforcement. In many regions, signs of degradation, such as cracks in the cover concrete, become apparent within just a few years after construction. This study primarily aims to investigate how the quality of locally sourced concrete in five different regions of Morocco impacts its resistance to carbonation. For each region, two concrete formulations were prepared using the Dreux Gorisse method. One formulation closely mimicked the constituents of the local mixtures, while the other incorporated a corrective sand blend to enhance gradation and fineness modulus, thereby aiming to improve carbonation resistance. The findings reveal that local concrete exhibits a higher carbonation rate compared to the Dreux Gorisse formulated concretes. Reducing the water-to-cement ratio (w/cm) and incorporating corrective sand effectively reduced the carbonation rate in the concretes. Interestingly, the comparison also revealed that the presence of carbon dioxide had a pore-reducing effect.

Keywords: reinforced concrete, deterioration, carbonation, corrosion, Dreux Gorisse method

05-036 Avantages d'utilisation des ciments à forts ajouts de calcaire et pouzzolane dans la fabrication des Bétons compactés aux Rouleaux

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Résumé

Au Maroc, l'utilisation des fillers calcaires et du sable fillérisé dans la composition des Bétons Compactés aux Rouleaux (BCR) destinés à la construction des barrages est une pratique courante depuis de nombreuses années. Cependant, la disponibilité de ces matériaux sur les sites de construction actuels et futurs se fait de plus en plus rare.

Pour faire face à ce défi, nous avons cherché des substituts pour les fillers calcaires et le sable fillérisé dans la composition des BCR. Nous avons choisi d'utiliser des ciments riches en calcaire (CPJ) et/ou en pouzzolane (CPZ) comme substituts. Nous avons préparé quatre mélanges différents, deux contenant du CPJ à 35% de calcaire à différents dosages et deux autres contenant du CPZ à 45% de pouzzolanes aussi à des dosages différents. Les performances mécaniques (résistance à la compression et à la flexion) et physiques (porosité et densité) de ces mélanges ont été comparées à celles d'une formule témoin contenant des fillers calcaires et du sable fillérisé.

Les résultats obtenus indiquent que l'utilisation des deux types de ciments permet d'obtenir des résistances à la compression satisfaisantes à 28 et 90 jours. De plus, une extrapolation des résultats à long terme suggère que des dosages réduits des deux ciments sont suffisants pour atteindre les résistances minimales de 10 MPa (valeur minimale prescrite pour les barrages au Maroc) à partir de l'âge de 3 ans. Par ailleurs, les masses volumiques des quatre formules de BCR se sont avérées parfaitement adaptées pour la construction de grands ouvrages tels que les barrages.

Mots clés : *Barrage en BCR, fillers, ciment enrichi en ajouts, performances mécaniques, performances physiques*

05-47 Massifs expérimentaux comparatifs de différentes compositions de béton compacté au rouleau destinés à la construction des barrages

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Résumé

Les barrages en Béton compacté au rouleau (BCR) sont des ouvrages très massifs qui nécessitent la mise en place de grands volumes de béton et qui doivent répondre à des normes de qualité précises.

Pour assurer leur réalisation dans de bonnes conditions de construction et de qualité, nous avons procédé à la réalisation de massifs expérimentaux aussi appelés planches d'essai, dont les principaux objectifs sont la mise au point du processus général de mise en œuvre et la vérification in-situ des caractéristiques du BCR. Nous avons adopté pour chaque massif expérimental un volume de 2000 m³ de BCR, réalisé en 7 couches de 30 cm d'épaisseur, avec des formulations différentes exprimés sous la forme F/S/C qui désignent respectivement Filler (fines), Sable 0/4mm et le dosage en Ciment.

Au terme des différents essais et mesures in situ (Densité, teneur en eau, porosité, résistance à la compression et à la traction, essai lugeons, ...etc.), les résultats obtenus permettent de distinguer deux formulations aptes à être adoptées pour le corps du barrage.

Mots clés : *Béton compacté au rouleau, massif expérimental, porosité, densité, résistance*