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Ministry of Higher Education and Scientific Research

University Yahia Fares of Medea
Faculty of Technology



Department of Civil Engineering and Laboratory of Materials and Environment (LME)



Certificate of Participation

This certificate is proudly awarded to speaker

MESSAAD Mokhtar

Who has successfully participated at the **1st National Conference on Civil Engineering and Environment "NCC2E'21"** from **08 to 09 December 2021** at **Medea – Algeria**

By presenting a communication entitled:

Modal behavior of Oued Fodda concrete dam

General Chair of the Conference

Co-author (s):

OUZANDJA Djamel

General Chair of NCC2E'21

Dr. GUENDOZ Mohamed





Modal behavior of Oued Fodda concrete dam

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Abstract

Gravity dams are fluid – structure – soil interaction problems. One of the most important problems in evaluation of dynamic behavior of concrete gravity dams is soil-structure interaction phenomenon. A parametric study was performed in the present work to view the combined effect of soil foundation. the Oued Fodda concrete gravity dam located in Chlef (northwestern Algeria) is selected as an example.

Three approaches are adopted to investigate the soil-structure interaction phenomenon: the fixed support foundation, the massless soil foundation and the mass soil foundation and also the hydrodynamic pressure of the reservoir water is modeled as added mass using the Westergaard approach.

As conclusion, it is clear that taking into account the soil structure interaction effect leads to a decrease in the modal frequencies even if the reservoir water is present.

Key words

Soil-structure interaction, modal behavior, fluid-structure interaction

- Introduction

Concrete gravity dams represent complex constructive systems of strategic importance. They are particularly used for electricity generation, water supply, flood control, irri-gation, recreation, and other purposes. They are a fundamental part of the society's infrastructure system ..

The response of a structure during an earthquake depends on the characteristics of the seismic signal, ground of foundation and of the structure itself. Thus, movement of the foundation is usually different from the movement in free field. This is due to the soil-structure coupling during the earthquake, this phenomenon is known in the literature as "Soil-structure interaction" also in case of the fluid exists, the phenomenon becomes more complicated, known as the "soil-fluid-structure interaction", Concrete gravity dams are part of this phenomenon [1], [2], [3].

The richness of literature on the soil-structure interaction reflects both the complexity and the interest on phenomenon which have gained more researches about it.

In consideration of the soil-structure interaction for the purpose to include in the deformation modes, the movements at the base of the structure, is a way to get a better approximation of the frequency of vibration of the coupled system which will be shorter than the system frequency with rigid base. In the literature, there are three models for modeling the soil-structure interaction phenomenon: the model of a fixed base, the second model with foundation modeled without taking into account its mass, and the third model with foundation taking into account its mass.

The dam reservoir interaction problems can be analysed using the three famous approaches: Westergaard, the approach of Lagrange and that of Euler.

In this paper, influence of the foundation soil on the modal response of the Oued Fodda



dam-foundation soil is investigated. For the modeling of the different cases of the dam in question, the finite element code ANSYS has been chosen.

- Dam-foundation Soil Finite Element Models

.1. Material properties of Oued Fodda dam

The Oued Fodda concrete gravity dam is located approximately 20 km of Oued Fodda (Chlef), in northwestern of Algeria, and founded over a massive limestone known as “Koudiat Larouah”. The capacity of the dam is 125.5 hm³ . The maximum height “H” and base width of the dam are 101 m and 67.5 m, respectively. The dam crest is 5 m wide and the maximum height of the reservoir water is considered as 96.4 m. The material properties of Oued Fodda dam including its foundation are reported in Table 1 below:

Table 1. Material properties of Oued Fodda concrete gravity Dam

Material	Material properties		
	Modulus of elasticity (MPa)	Poisson's ratio	Mass density (kg/m ³)
Concrete (dam)	24600	0.20	2640
Rock (foundation)	20000	0.33	2000

.2. Finite Element Model of Dam-Foundation System

The effect of soil-fluid-structure interaction on the behavior of the Oued fodda dam has been modeled and studied using the ANSYS code. Three approaches are adopted to investigate the soil-structure interaction phenomenon:

- The fixed support foundation.
- The massless soil foundation, neglecting the mass of this foundation and therefore of the inertial component of the interaction.
- The mass soil foundation, taking into account the mass of this foundation and therefore the inertial component of the interaction.

The dam-foundation soil structure is investigated using three 3D finite element models, The SOLID185 type element available in the ANSYS code library was used to model the body of the dam as well as the foundation soil.

The figure 1 shows the fixed support foundation, without taking into account the phenomenon of soil-structure interaction:

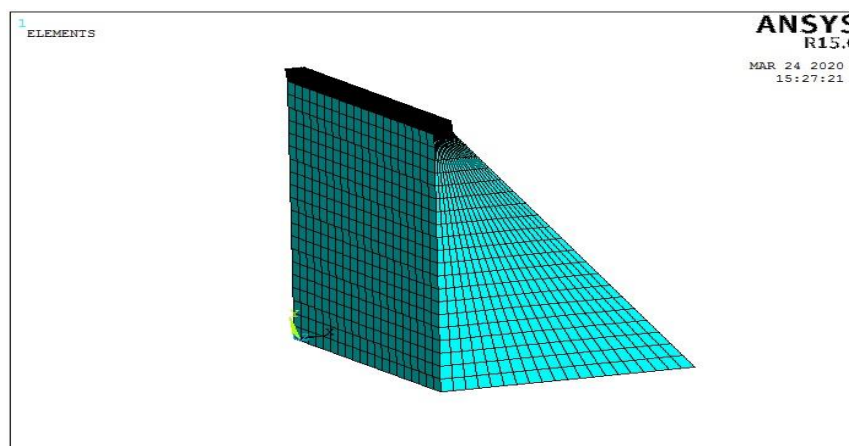


Fig.1. 3D finite element model of Oued Fodda dam without adjacent soil

The figure 2 represents the model of the dam with soil of foundation, the dimensions of the soil according to x, y and z were chosen after a study of sensitivity of the model to the dimensions of the soil, the extensions of the foundation soil are 3h of the dam in all directions:

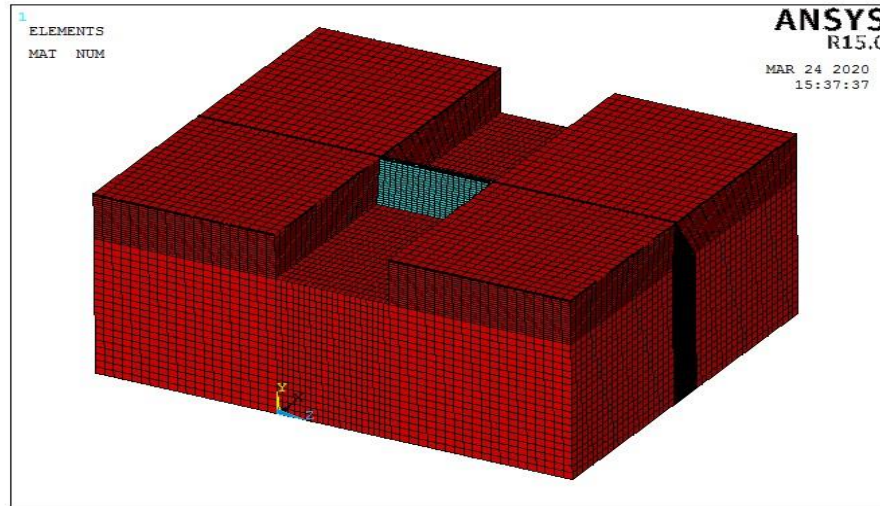


Fig.2. 3D finite element model of Oued Fooda dam with adjacent soil

For the fluid, the model of added masses (equivalent to the westergaard approach) using the SURF element available in the Ansys code library was used.

3. Results and discussions

3.1. Modeling of soil-structure interaction

The Figures 3, 4 and 5 respectively show the fundamental mode of the dam alone (fixed base), dam with soil without mass (not heavy) and dam with soil with mass (heavy).

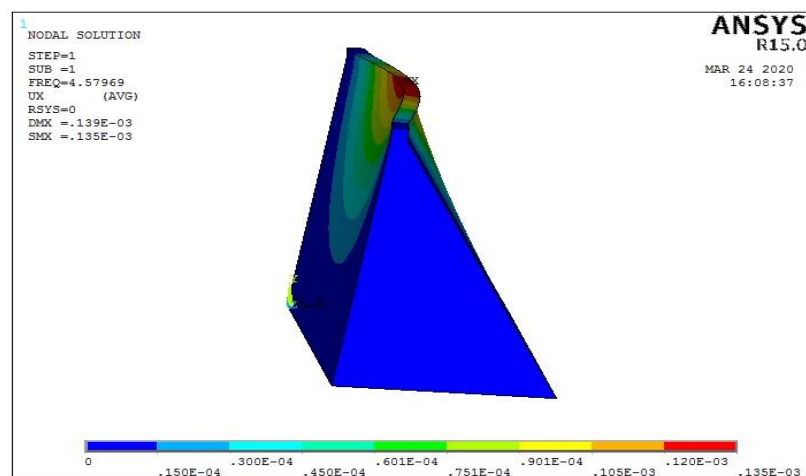


Fig.3. Dam without soil foundation

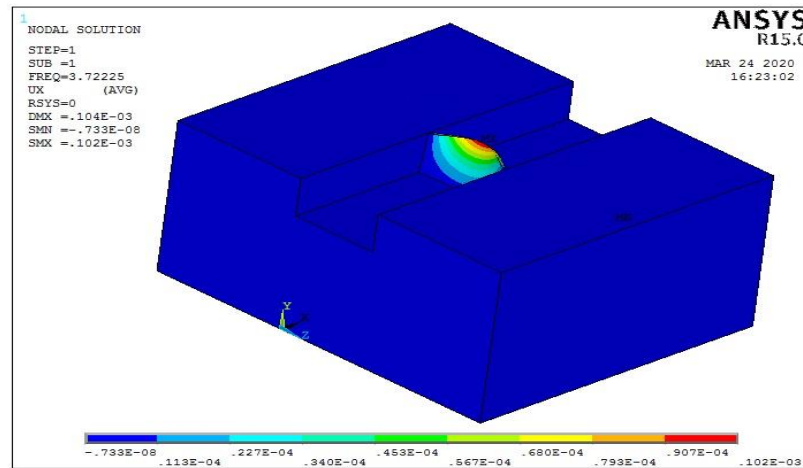


Fig.4. Dam with massless soil foundation

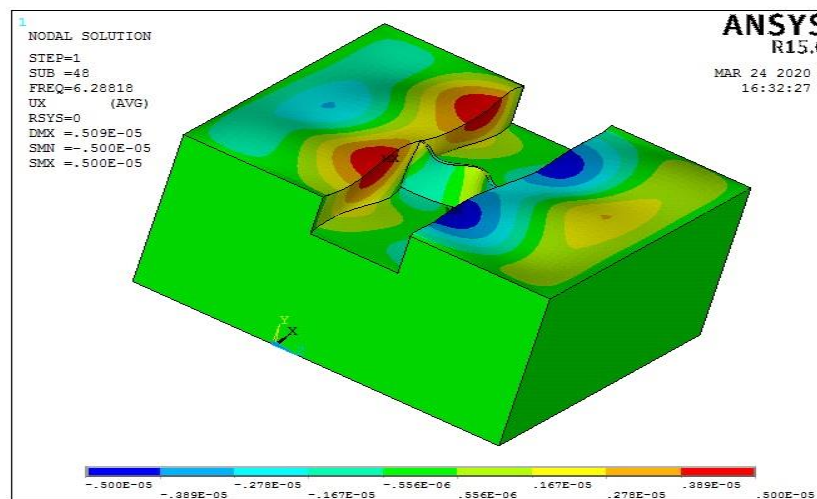


Fig.5. Dam with mass soil foundation

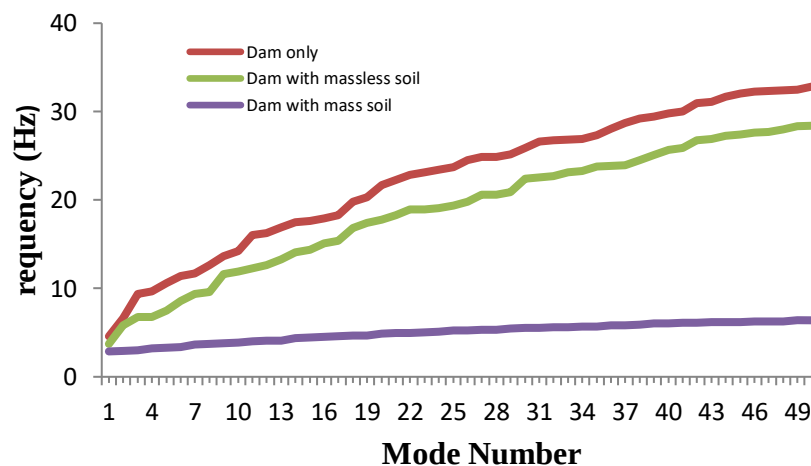


Fig.6. Effect of soil-structure interaction on behaviour

Figure 6 represents the modal frequencies for the case of dam with fixed support with empty reservoir, the case of dam with massless soil foundation with empty reservoir and the case of dam with mass soil foundation with empty reservoir, it should be noted that the number of modes is chosen in such a way that the sum of the masses trained by these modes reached 90% of the total mass. It is clear that adding soil to dam in the modelling which means taking into account the soil structure interaction effect leads to a decrease in the modal frequencies values furthermore for the mass soil



foundation model. Adding the foundation soil to the structure, makes the system flexible and increases its mass which generates a decrease in system frequency and therefore an increase in his period.

The same results were found for the arch weight dam of el Bayadh [4], [5].

According to the three figures: 3, 4 and 5, we note that the modeling of the foundation soil modifies not only the values of the frequency but also the positioning of the fundamental mode.

3.2. Modeling of fluid-structure interaction

The second application consists in modeling the fluid structure interaction, for this purpose the dam is considered full. For each soil-structure interaction model, two analyzes were carried out with and without fluid. The added mass approach was used to model the fluid. Using the ANSYS code, the SURF154 element available in the ANSYS library allows this approach to be represented. This involves distributing the mass of the fluid over the contact surface between the reservoir and the dam and / or foundation soil.

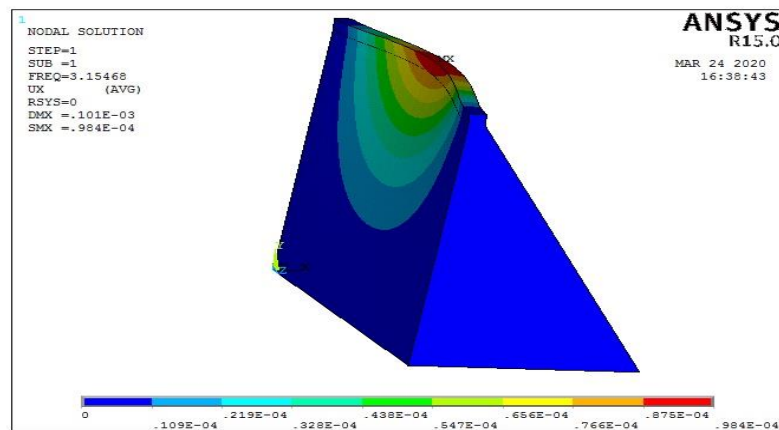


Fig.7. Dam without soil foundation with fluid

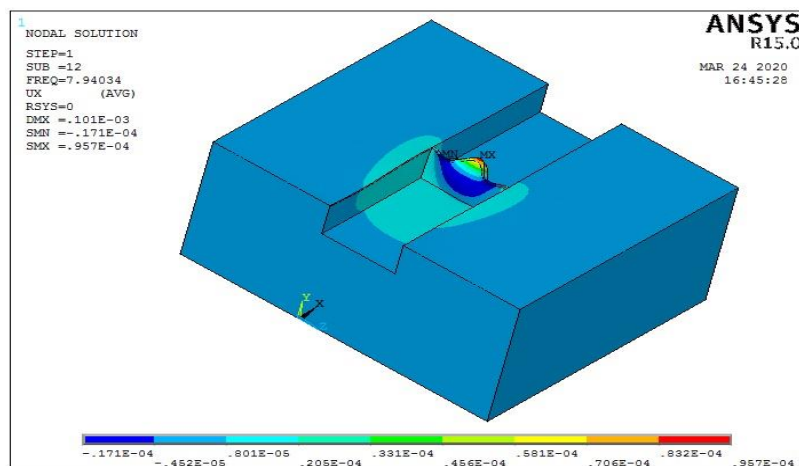


Fig.8. Dam with massless soil foundation with fluid

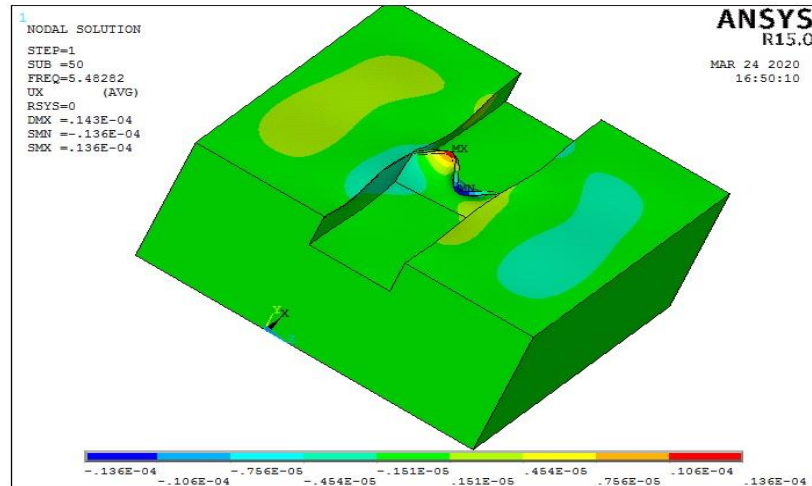


Fig.9. Dam with mass soil foundation with fluid

Figures 7, 8 and 9 respectively show the fundamental mode of the dam alone (fixed base), dam with soil without mass and dam with soil with mass taking into account the presence of the fluid.

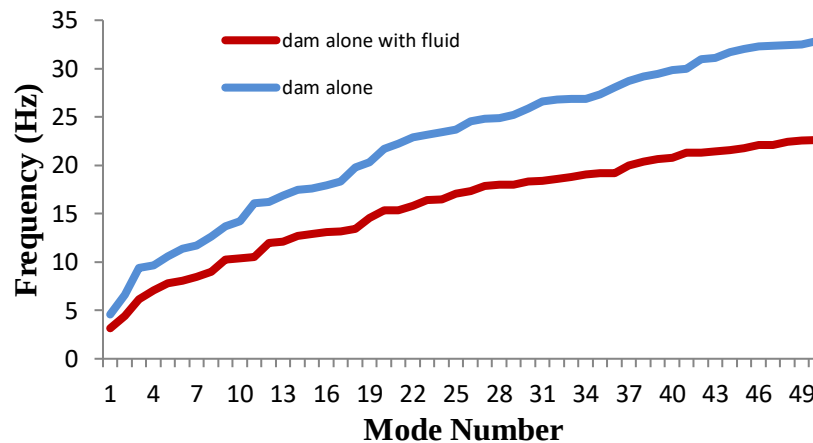


Fig.10. Effect of fluid-structure interaction on behavior

Figure 10 shows the effect of fluid structure interaction modeling on the modal behavior of the dam alone, i.e. without soil-structure interaction modeling. It is clear in Figure 10 that the presence of the fluid decreases the frequency of the system.

The same results as those of the fixed base dam have were found for the dam modeled with soil massless foundation and massed foundation soil.

3.3. Modeling of Soil-fluid-structure interaction

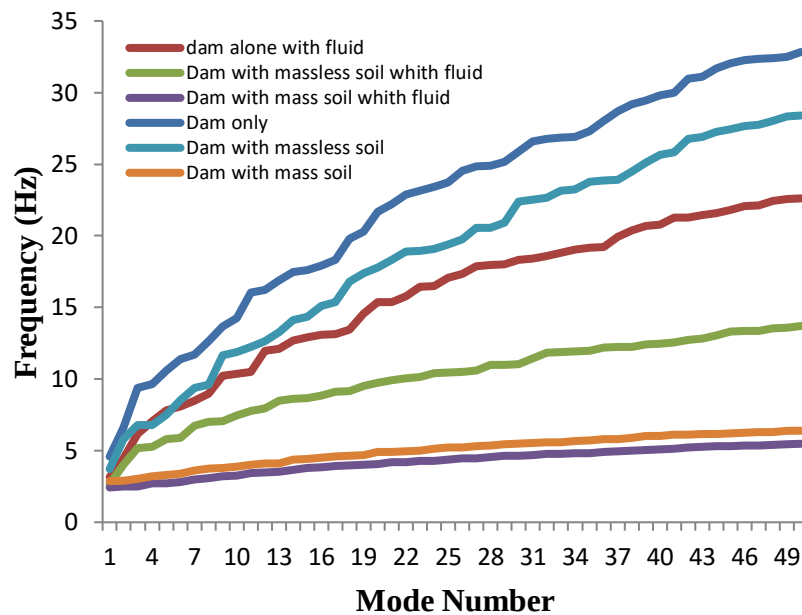


Fig.11. Effect of Soil-fluid-structure interaction on behavior

Figure 11 represents the effect of interaction soil-structure and the presence of the fluid on the modal behavior of the Oued Fodda dam, it shows that the modeling of ISS as that of the fluid have the same effect on the modal behavior is to decrease the frequency of the system.

4. Conclusion

In this article, a parametric study was carried out for the concrete dam "Oued Fodda" using the finite element code "ANSYS" to see the effect of the phenomenon of soil-fluid-structure interaction on the modal behavior of the system.

The modeling of soil structure interaction modifies the frequency of the dam, knowing that the frequency is a dynamic characteristic to be taken into account in the different types of dynamic calculation (spectral, transient ...)

The study had shown that reservoir water presence and soil foundation modelling have the same effect on the modal frequencies results which means on the modal behaviour of the concrete dam, they decrease the frequencies values.

References

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SCIENTIFIC PROGRAMME

1st National Conference on Civil Engineering and Environment

NCC2E'21

08 – 09 December 2021 at Medea – Algeria

<http://www.univ-medea.dz/NCC2E21/>

PROGRAM NCC2E'21

08 December 2021

08h00 – 09h00	Registration, Medea University		
09h00 – 09h30	Opening Ceremony Pr. BOUAROURI Djaafar, Rector of Yahia Fares University Dr. BACHENE Mourad, Dean of Faculty of Technology, University of Médéa Dr. GUENDOOUZ Mohamed, General Chair of NCC2E'21, University of Médéa		
09h30 – 10h00	Coffee break		
10h00 – 12h00	Oral Sessions		
	Session 1 Structures Engineering	Session 2 Materials and Environment	Session 3 Geotechnical and Engineering
12h00 – 13h30	Lunch		
13h30 – 15h30	Oral Sessions		
	Session 1 Structures Engineering	Session 2 Materials and Environment	Session 3 Geotechnical and Engineering
15h30 – 16h00	Coffee break		

09 December 2021

08h30 – 09h30	Registration, Medea University		
09h30 – 10h00	Coffee break		
10h00 – 12h00	Oral Sessions		
	Session 1 Structures Engineering	Session 2 Materials and Environment	Session 3 Geotechnical and Engineering
12h00 – 13h30	Lunch		
13h30 – 14h30	Closing Ceremony		

08 December 2021

Session 1 : Structures Engineering

10h00 – 12h00	N°	Author	Title
	01	BOUHADRA Abdelhakim	Effet de la fondation élastique variable sur le comportement des plaques FGM
	02	MESBAH Abdelhak	Contribution à l'analyse vibratoire et au flambage des poutres en FGM par la méthode des éléments finis
	03	MENASRIA Abderrahmane	Analyse de stabilité thermique des plaques sandwiches en FGM en utilisant une théorie d'ordre élevé
	04	CHABANI Abdelmadjid	Modélisation et simulation d'un système stochastique : Cas d'une structure (d'un système) à un seul degré de liberté
	05	AIT YAHIA Sihame	Dynamic and wave propagation study for anisotropic plates using refined shear deformation theory
	06	BOUZERIBA Asma	Un élément secteur pour l'analyse des cylindres multicouches sous pression et température
	07	BOUMEZBEUR Khaled	Modélisation numériques du comportement mécanique d'une poutre en matériaux à gradient fonctionnel-Application de la méthode des éléments finis
	08	CHETTAH Mahieddine	Parametric study on dynamic response of a subjected to moving load
	09	CHIBA El Houcine	Experimental investigation of rail expansion and contraction in railway bridges
	10	CHATBI Mohamed	Analyse vibrationnelle des poutres composites renforcées par des nano-fibres en carbone alignée et aléatoirement orientés.

08 December 2021

Session 2 : Materials and Environment

10h00 – 12h00	N°	Author	Title
	01	SMAIDA Ali	Utilisation de GNT (TAICHA) comme matériau de construction dans les couches des chaussées
	02	BOUBAKEUR Asmaa	Durabilité du mortier autoplaçant à base de metakaolin
	03	BEDADI Laid	Caractérisation des sables des oueds pour leur valorisation dans les domaines de fabrication de béton
	04	BENYAMINA Smain	Effet du sable de concassage sur le comportement d'un béton autoplaçant
	05	BAYAH Meriem	Impact du sable recyclé sur le comportement du béton autoplaçant
	06	BENCHOUAF Amina	Comportement physico-mécanique du béton de sable allège par du polystyrène granule
	07	BEN RAMOUL Lamia	Etude numérique des caractéristiques de l'écoulement de la dispersion des polluants à l'aide de trois modèle fermeture de turbulence RANS
	08	BOUKOUR Salima	Effet des granulats de caoutchouc et des déchets de brique sur les performances physico-mécanique des mortiers renforcés par du latex résineux
	09	BOUKSANI Omar	Influence of algerian bentonite on hardened properties of mortars
	10	BOULEGHEBAR Yasmina	Utilisation de déchets de verre dans le mortier
	11	RABEHI Rachid	Apport de fibre métallique sur les caractéristiques du béton autoplaçant à l'état durci à base de gravier de béton recyclé.
	12	KHEZZANE Abdenour	Etude expérimentale sur les propriétés du béton drainant sous influence de la taille des granulats.

08 December 2021

Session 3 : Geotechnical and Engineering

10h00 – 12h00	N°	Author	Title
	01	BENSAADA Abdelhalim	Contribution à l'amélioration des propriétés mécaniques d'un enrobé bitumineux modifié par les déchets plastiques
	02	DJERMANE Abdelkader	Méthode d'interpolation spatiale. Application aux données géotechniques
	03	AMRI Salima	Influence de sable de dune sur le comportement mécanique et thermique d'une argile très plastique
	04	BAHLOUL Ouassila	Effet de l'influence du cation Mg^{++} sur les sols non saturés (cas d'un sol gonflant)
	05	SARI AHMED Billal	Evaluation empirique de quelques facteurs contrôlant l'effet de la chaux sur la plasticité des sols argileux stabilisés
	06	BOUKEFFOUSSA El roul Abdelnacer	Effet des propriétés des fibres sur le comportement d'un sol sableux renforcé par fibre aléatoirement distribué
	07	DENINE Sidali	Effect of confining pressure on the behavior of geotextile reinforced sand

08 December 2021

Session 1 : Structures Engineering

13h30 – 15h30	N°	Author	Title
	01	GUEDOURA Hamda	Strengthening web post buckling of cellular beams using CFRP
	02	KHEBIZI Mourad	Modélisation de la réponse mécanique d'une poutre composite en matériaux à gradient fonctionnel (FGM) par l'utilisation de la solution tridimensionnelle de Saint-Venant
	03	GUIZ Amine	Estimation de la fonction de cohérence à partir des données sismiques
	04	HADJBOULENOUAR Rachid	Analyse numérique tridimensionnelle d'un assemblage collé à base d'adhésif nanocomposite Epoxy/Al ₂ O ₃
	05	DIF Hamza	Site effects seismic damage assessment : application for the RC frame model building.
	06	HASSOUNE Mohammed	Analyse numérique de l'effet de l'incendie sur le comportement des panneaux de profilés laminés à froid
	07	BENAMEUR Imad	Analyse du comportement mécanique à la flexion des plaques sandwiches à gradient variable type FGM
	08	KOUIDER Nadia	Analyse numérique de la propagation des fissures et leurs réparations dans les profilés reconstitués soudés
	09	GUENDOZ Ilyes	Bending-torsional behavior of the FGM beam with consideration of 3D effects

08 December 2021

Session 2 : Materials and Environment

13h30 – 15h30	N°	Author	Title
	01	STTARI Chafika	Comportement des mortiers à l'état frais sous l'effet du degré de saturation des sables recyclés
	02	DIF Fodil	Effet de la poudre pouzzolane naturelle sur les propriétés physiques-mécaniques et thermique d'éco-béton de construction.
	03	BRAHIMI Mouna	L'effet des conditions climatiques de la ville de Béchar sur le comportement du béton au jeune âge
	04	DOUARA Taha-Hocine	Effets des différents régimes de durcissement sur les propriétés mécaniques du béton autoplaçant à base de sable de dune
	05	BOUABDALLAH Fouzia	Durabilité des éléments en béton dans un environnement favorisant L'AGR / Simulations numérique et expérimentale
	06	KECHKAR Chiraz	Etude expérimentale des propriétés physico-mécaniques des bétons élaborés à base de poudrettes de caoutchouc
	07	HEIBA Noussaiba	Utilisation potentielle du sable recycle dans le béton de sable
	08	RABEHI Rachid	Comportement du béton autoplaçant (BAP) en présence de poudre de verre
	09	DJEBIEN Rachid	Effet d'ajout de poudre de céramique et poudre de CKD sur la durabilité du mortier «Etude comparative»
	10	KALLOU Amel	Performance des BTC à base de fibres végétales
	11	GUESMI Amira	Bio-waste materials as potential sustainable precursors used for activated carbon production : Equilibrium and kinetics study of phenols removal

08 December 2021

Session 3 : Geotechnical and Engineering

13h30 – 15h30	N°	Author	Title
	01	SAIDANI Douadi	Study of the effect of preloading sandy soils on shear strength by the discrete method-DEM
	02	DOUIFI Amel	Evaluation of Ø-based p-y curves in lateral response of large diameter monopiles in sand
	03	HEBBACHE Kamel	Utilisation de la tomographie électrique pour la modélisation des cavités souterraines
	04	TAIBI Amine	Correlation between the coefficient of uniformity ratio and particle form characteristics of binary sized mixtures
	05	DAOUDI Mohamed Habib	Comportement modal du système «Barrage a voutes multiples» Fondation rocheuse» de BENI-BAHDEL (analyse modale non amortie)
	06	HENADER Abderrahmane	Influence de l'état initial du sol sur la résistance au cisaillement d'un mélange sol-fibre
	07	MEKKI Feriel	A parametric study on collapse load of ground anchor in frictional soil using upper bound theorem

09 December 2021

Session 1 : Structures Engineering

10h00 – 12h00	N°	Author	Title
	01	KORIGA Said	Etude de l'adaptabilité des assemblages semi-rigides dans les structures métalliques selon les RPA99V2003 en utilisant un modèle numérique développé
	02	METROUNI Tarek	Analyse non linéaire géométrique des systèmes de tensegrité
	03	KOUIDER Nadia	Etude numérique de la performance des poteaux mixtes (Acier-béton) comprimés
	04	KECIR Amar	Etude de comportement des nano-poutres en vibration libre en utilisant la théorie non-local
	05	NEDJHIOUI Oussama	Numerical study of a reinforced concrete beam strengthened by CFRP sheets using ABAQUS
	06	MADI Rafik	Réhabilitation des anciennes constructions vis-à-vis du séisme
	07	REFRAFI Salah	Etude du flambement mécanique sur les plaques sandwiches fonctionnellement graduées reposantes sur des fondations élastiques
	08	LARDJAME Samia	Non-linear finite element modeling of cracking thermal loads of GFRP bars-reinforced concrete slabs under temperature and mechanical load
	09	ZITOUNI Mohamed	Effet de l'ajout de fibres de verre sur le comportement thermique des poutres en béton armé

09 December 2021

Session 2 : Materials and Environment

	N°	Author	Title
10h00 – 12h00	01	KOUIDER DJELLOUL Omar	Absorption capillaire et la résistance à la compression de béton autoplaçant à base des granulats recyclés
	02	HADID Lamia	Analyse numérique des défauts dans les biomatériaux
	03	MESSAAD Mokhtar	Modal behavior of Oued Fodda concrete dam
	04	METAHRI Aicha	Numerical analysis the effect of ratio of reinforcement of particle on SIF in composite material
	05	GUERBAS Nabil	Evaluation d'utilisation des additions minérales et organiques sur les propriétés rhéologique d'un mortier à base du sable de concassage
	06	TEBBAL Nadia	Effect of high temperature and air entraining agent on the characteristics of the mortar
	07	REBOUH Redouane	Prévision de la résistance à la compression du béton contenant de la pouzzolane naturelle par l'approche hybride « Réseau de Neurone-Algorithme Génétique»
	08	RAMDANE Rihab	Etude d'un béton hydraulique contenant des cendres de biomasse
	09	IRKI Ilyes	Activation chimique de la poudre de brique cuite sur le mortier durci
	10	BRAHIMI Mouna	L'effet de température et de la vitesse du vent sur le béton au jeune âge
	11	SEBOUI Hatem	A review on the estimation of the mechanical properties in historical masonry building
	12	MELAIS Fatma Zohra	Valorisation des coquillages marins dans l'élaboration des bétons drainants

09 December 2021

Session 3 : Geotechnical and Engineering

10h00 – 12h00	N°	Author	Title
	01	EZZIANE Mohamed	Influence des fines siliceuses sur le comportement au compactage des tufs de la région de Chlef
	02	ZAIRI SEYYID-Ahmed	Etude du comportement au cisaillement d'un sol sableux de Chlef renforcé par un mélange fines-fibre
	03	DOUIFI Amel	Evaluation of Ø-based p-y by predicting the natural frequency of an OWT based on a monopile
	04	MEROUANE Youcef	Effets des incertitudes des propriétés du sol sur l'allongement de la période d'une structure en tenant compte de l'interaction sol-structure
	05	MEZIANI Brahim	Etude des glissements de terrain à l'aide des données géologiques et géotechniques : Une étude de cas du glissement de Boufharma (Tizi-Ouzou, Algérie)