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Improvement of facilitated Jacket platform model using mixed dimensional coupling theory and modal testing

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ABSTRACT

The jacket structure is the key facility for the exploitation of marine resources. Offshore oil platforms located in an earthquake zone need to be analyzed for the structural response. A real offshore structure is always intricate and has to be idealized to diverse degree to fit in to the framework of the mathematical model for dynamic analysis. This work addresses the need for such a facilitated structural computation model. The planned scheme is based on laboratory work for improving the facilitated model. This study describes the scheme in employing the MDC associated with the GA method to create and update the facilitated structural model for analyzing the responses of a jacket platform. The facilitated modelling is first calculated based on MDC method, and then the platform model is refined and improved based on recorded modal features. Considering the presented model, the expense of analysis of jacket offshore structures is considerably reduced without incurring any loss of precision. Therefore, improvement of such approaches would be acutely beneficial to spread out technologies that can be applied for jacket structures with saving of both time and cost.

1. Introduction

Given the existence of oil and gas reserves in the depths of the seas, it is important to select the desired structures for oil extraction from these seas. Jacket Type Offshore Platforms (JTOP) are one of the most important civil structures that play a very important role in the exploitation of oil and gas resources and reserves in offshore areas. JTOP are the most common type of offshore structures in the Persian Gulf region. Jacket structures have many interconnected elements, which leads to complexity of calculations, time-consuming and costly calculations, and the uncertainty in the results of the analysis of such structures. thus, in order to overcome these challenges, a simplified or idealized analytical model based on dimensional reduction in structural elements can be used [1]. For this purpose, Mixed-Dimensional Coupling (MDC) method is employed in this paper. In very Finite Element Analysis (FEA) models, there are generally areas that are ideal candidates for dimensional reduction. In order to catch stress concentrations at positional components, combining the reduced or less dimensional element types with upper dimensional elements in the whole global model can be useful. A method of connecting the beam elements to the three-dimensional sequence elements at each interface in the model is needed [2]. Employing this skill, lengthy slender areas of constant cross-section can be reduced to their tantamount 1D beam element, whenever complex areas (because of geometry, loading or material behavior) are modelled utilizing full three-dimensional analysis. This facilitates effectual modelling of complex structures (such as offshore platforms) and results in substantial cost savings for each computational analysis or the ability to run larger analyses [3].

As a result, it can be said that in this paper, calculations volume (relying on MDC strategy) and uncertainty (relying on model refining based on vibration data) are reduced in the FEA of an engineering structure. The FE model updating is a numerical method used to reduce the difference between the responses of the real structure and the finite element (numerical) model. In other words, the structure resulting from the model updating process will be more compatible with the physical model. In fact, the FE model updating method is necessary an optimization approach; its purpose is to reduce the interval between the measured data and the predicted information from the analytical model. In this research, recorded modal features have been considered to determine the optimization objective function. In this regard, an intelligent computational method (genetic optimization algorithm) has been utilized [4].

The theory of uncertainty, or in other words, model updating, has made considerable progress in recent years. Numerous researches have been done in the field of model updating and reduction of the model, which are briefly mentioned below. [5] investigated an improved method based on model modal reduction to update the model and monitor the health of a jacket platform. The results showed that the ameliorated iteration method eliminates the destructive effects of the model reduction method on the proposed method [6]. The uncertainty of a JTOP is presented using the updated numerical model update method. The results showed, not only reducing both structural and parametric uncertainties is essential, but also calibrating the damping matrix for updating a numerical model and improving the FE model accuracy is of great importance. The developed methodology, which is applied to a sophisticated structural system, is strongly recommended for updating the systems that existence of an accurate updated numerical model is essential [7]. An experimental study was presented to update the structural model of an offshore platform using the model crossover method. The results illustrate that the present method is effective for the model updating of offshore platform structures with a minimal value of lower-order, spatially incomplete experimental modal data. [8] proposed a SIM strategy for offshore jacket platforms based on the FE model updating and a novel simplified method. The results indicate that the presented new technique is completely successful in conducing damage identification in jacket structures. On the other hand [9] published a new iterative method for model updating based on model reduction. The results indicate that the convergence rate and the computing time of the new method are significantly superior to those of the traditional iterative method with or without noise. In order to circumvent problems such as high degrees of freedom and imperfect experimental data a reduced model is used [10,11]. [12] conducted research on reduction-based model updating of a scaled offshore platform structure. The whole process consists of three steps: reduction of FE model, the first model updating to minimize the reduction error, and the second model updating to minimize the modeling error of the reduced model and the real structure. A comparison between the real structure and its numerical models shown that the updated models have good approximation to the real structure. Besides, some difficulties in the field of model updating are also discussed. [13] suggested a FEM updating method for offshore jacket structures using measured incomplete modal data. In this study, the results indicate that proposed technique is computationally efficacious since it does not requirement iterations. It updates the mass and stiffness matrix such that they are compatible with the modal data of the observed modes. [14] studied model-reduction techniques for Bayesian FE model updating using dynamic response data. In this study, substructure coupling techniques for dynamic analysis are proposed to reduce the computational cost preoccupied in the dynamic re-analyses. The effectiveness of the proposed strategy is demonstrated with identification and model updating applications for finite element building models using simulated seismic response data. In another study, [15] performed a finite element model updating using damping matrices. A damping-based upgrade method proposed and investigated with the aim that the updated finite element model has an accurate mechanism for predicting the measured response-frequency functions. [16] investigated damage detection in an offshore platform using incomplete noisy FRF data by a novel Bayesian model updating method. According to the results, the introduced method is totally successful in the model updating and damage tracing of the jacket platform. The results also indicate the lower effects of uncertainties and noise levels in damage tracing outcomes. [17] examined damage detection in an offshore Jacket platform using genetic algorithm based finite element model updating with noisy modal data. The results show that this method can detect the damage of this kind of structure satisfactorily even if modal data is not precisely obtained. [18] used response-frequency functions and natural frequencies to update the model in structures. A minimum squares method with proper normalization used to solve a given system with noisy datums. The method of sensitivity and proper selection of the measured frequency data resulted in better accuracy and convergence of the FE update process. [19] developed an effective numerical method for updating the FE model of damping gyroscopic systems. This method integrates the measured modal data with the finite element model to create a finite element model that results in gyroscopic and damping matrices that clearly reproduce the experimental modal data. [20] suggested updating methods for probability-informed inspection planning for offshore structures. The process for updating the probability of failure after inspection programmed in match with these principles based on Monte-Carlo simulations and Bayesian parameter updating. The application of these principles and the proposed process illustrated by an example calculation resulting in an example of inspection intervals for a jacket structure. Accurate prediction of collapse behavior is essential for long-life oil rigs. In this regard, the FE method can be used to simulate the behavior of intricate geometric connections [21].

Significant reductions in the analysis time of jacket structures are available with minimal uncertainty effects, if idealization techniques (such as the use of MDC method) are applied to the study model. The main purpose of this article is to update the structural model of the jacket platform along with the dimensional reduction in structural elements in the model. As previously mentioned, in this paper, the MDC method is used to reduce the model and the genetic algorithm method is used to update the model simultaneously. To implement the proposed method, a physical model of the jacket platform constructed and an experimental modal analysis performed on it. The details of these methods are explained in Sections 2 and 3. As a result, in the present study, the purpose is to create a simple and useful computational model based on recorded modal features (i.e. improved facilitated model). This proposed structural model will have dynamic properties close to the actual behavior of the offshore platform structure. Considering the presented model, the expense of analysis of jacket offshore structures is considerably reduced without incurring any detriment of accuracy.

2. Facilitated model based on MDC theory

Finite element analysis (FEA) of an engineering structure nowadays are a usual way to recognize structural behavior and evaluate structural integrity. The FEA utilizing small-scale elements can generally develop the precision of numerical simulation of a structure but it can also lead to a huge computation cost or a difficulty to run. The FEA utilizing relatively large-scale elements may capture global structural behavior but it may not be able to identify local structural characteristic. The multi-scale finite element simulation can prepare an enhanced solution in this situation [1,22]. Consequently, it would be advisable to combine the reduced dimensional element types with higher dimensional elements in the whole global jacket structure models. But these reduced models give mathematical difficulties at the connections between the differing element types because of the incongruity of their nodal degrees of freedom. Hereof, some approach is essential to couple the differing element types. Using MDC scheme, lengthy slender areas of constant cross-section can be reduced to their equivalent 1D beam element, while complex areas (because of geometry, loading or material behavior) are modelled utilizing full 3D analysis [23,24]. A solution to the problem where beams are coupled to solids has been suggested by [25]. The main step is to analyze first how he stresses change over the cross-section of the beams and then equate the work done on both sides of the interface between dimensions. The standard strength of materials bending theory can be applied to predict the bending stress distribution, whilst the distribution of shear stress on the cross-section of the beam because of torsional moment or the action of shear force can be acquired utilizing the 2D stress functions [26]. For instance, the coupling formularization for the axial force case, as presented in Figure 1.

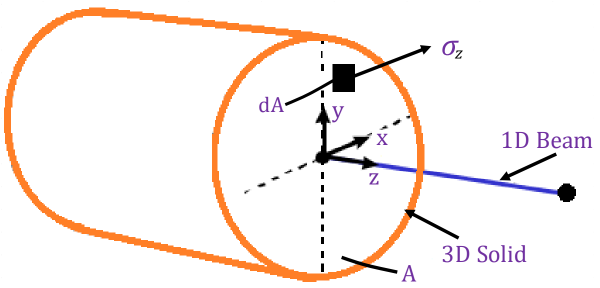

Figure 1- The coupling formulation

Equating the work done by the axial force acting on the 1D beam with the work accomplished by the surface stresses of the 3D body at the interface, the following Eq. (1), results:

$$F_Z W = \int_A \sigma_Z W dA \quad (1)$$

Where w denotes the beam axial displacement and W denotes the axial displacement in the 3D sequence. If the 3D area is long and slender, then the axial stress is alike over the cross-section and is described as Eq. (2):

$$\sigma_z = \frac{F_z}{A} \tag{2}$$

In the 3D model, the axial displacement at any point, in terms of the nodal displacements {W} and shape functions [N], can be expressed as Eq. (3):

$$W = [N]\{W\} \tag{3}$$

and we have Eq. (4):

$$Aw = \sum_{i=1}^{Nelements} \int_{A_i}^{0} [N] dA\{W\} = [B]\{W\} \tag{4}$$

Displacement compatibility between the 1D beam element and the adjoining 3D continuum elements can accordingly be enforced as a multipoint restriction Eq. (5), of the form:

$$-a_0 w + B_1W_1 + B_2W_2 + B_3W_3 + ... = 0 \tag{5}$$

Coupling equations are formed for the other five load cases (2 bending, 2 shear and torsion) in a similar way as above, all of which contain assessment of the stress distribution at the interface. For the bending moment load status's, the only non-zero stress is direct stress σ_z. For bending about the x axis, σ_z for both symmetric and unsymmetric sections can be expressed as Eq. (6):

$$\sigma_z = M_x(P.xQ.y) \tag{6}$$

Where Eq. (7), Eq. (8):

$$P = \left[\frac{I_{xy}}{I_{xy}^2 - I_{xx}I_{yy}}\right] \tag{7}$$

$$Q = \left[\frac{I_{xy}}{I_{xx}I_{yy} - I_{xy}^2}\right] \tag{8}$$

The diffusion of shear stress on the cross-section of a beam subjected to a torsional moment is calculated by considering a stress function. [26], illustrations that if a function $\emptyset(x, y)$, the Prandtl stress function, is supposed to exist such that Eq. (9), Eq. (10):

$$\tau_{xz} = \frac{\partial\phi}{\partial y} \tag{9}$$

$$\tau_{yz} = -\frac{\partial\phi}{\partial x} \tag{10}$$

then the stress function must satisfy the differential Eq. (11):

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + 2G\theta = 0 \tag{11}$$

where θ stand for the twist per unit length of the beam and G presents the shear modulus. Supposing that the co-ordinate axes are aligned with the principal axes of the cross-section, the stresses on the cross-section at any point (x, y) because of a shear force F_x are determined in terms of a stress function $\emptyset$ as Eq. (12) , Eq.(13):

$$\tau_{xz} = \frac{\partial\phi}{\partial y} - \frac{F_x x^2}{2I_{yy}} + \frac{\upsilon}{2(1+\upsilon)}\frac{F_x y^2}{I_{yy}} \tag{12}$$

$$\tau_{yz} = -\frac{\partial\phi}{\partial x} \tag{13}$$

So that Eq. (14):

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0 \tag{14}$$

with the boundary condition on the boundary of the section Eq. (15):

$$\phi = \frac{F_x}{I_{yy}}\int\frac{x^2}{2}dy - \frac{\upsilon}{2(1+\upsilon)}\frac{F_x y^3}{3I_{yy}} + const \tag{15}$$

The analysis of the shear stress can consequently be reduced to a heat transfer analysis, with boundary temperatures which change with x and y according to Eq. (15), The shear stress components can be derived utilizing the temperature gradients $\frac{\partial\emptyset}{\partial x}$ and $\frac{\partial\emptyset}{\partial y}$. The alteration of the stress function over any cross-section can be found considering the facilities available in standard finite element packages for conductive heat transfer and the shear stress on the cross-section can then be deduced from the resulting temperature gradients. The full technical details can be acquired from [24].

Figures 2 and 3 display the examples of beam-solid coupling. According to the results, there is no perturbation to the stresses around the interface and the results compare favorably with the analytical results. Figure 4 indications the application of this procedure to an offshore jacket structure which consists of six YT joints [24]. A full 3D model, Figure 4(a), and a mixed-dimensional model, Figure 4(b), have been analyzed and contours of Von Mises stress with identical scales are shown. For the above mixed-dimensioanal model, each substructure would display a single joint, as presented in Figure 4(c), connected to the global model via just four nodes. Furthermore, more detailed discussions can be found elsewhere [27,24].

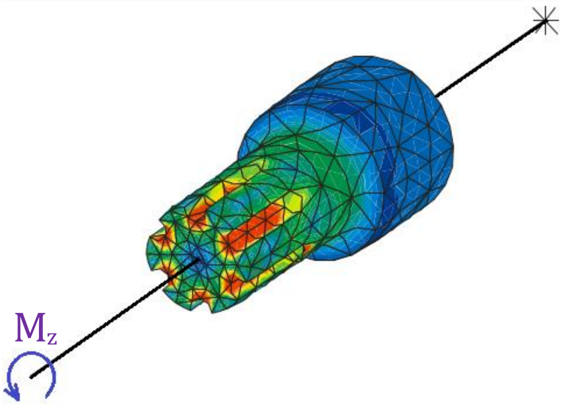

Figure 2- Von Mises stress on 3D model [27].

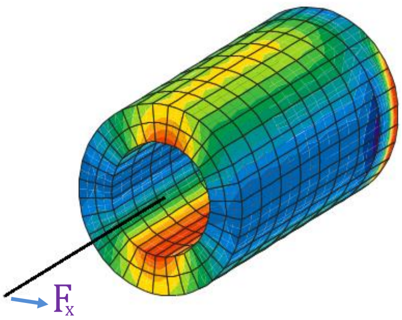

Figure 3- Shear stress τ_{xz} due to a shear force [27].

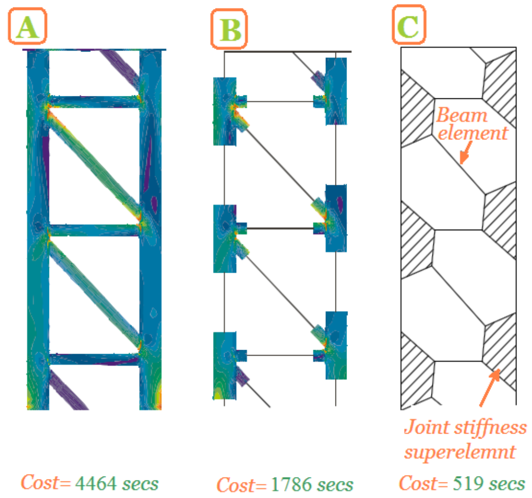

Figure 4-(A) Full 3D model, (B) 3D-1D model, (C) Superelement model [27].

3. Refining of the facilitated model

Genetic Algorithm (GA) are inspired by the science of genetics and Darwin's theory of evolution [28,29]. GA is based on the permanence of the fittest or natural selection. Also, GA is among the first population-based stochastic algorithms. The main operators in this algorithm include the processes of selection, crossover, and mutation [30]. GA is a powerful optimization method that performs a random and purposeful search for solution space. This scheme searches based on iteration. Genetic algorithms simulate the genetic evolution of living organisms. This technique is based on "the survival of the fittest" and "reproduction of the superior individuals". The objective is to find the best solution among the various solutions. Thus, this algorithm always moves towards the objective [31].

The GA starts with a set of random solutions (chromosomes) called populations. These solutions are used to produce the next population so that the newly produced populations are better than the old ones because the selection of new populations is according to their fitness. In the minimization problems, the chromosome with the lowest value of the modified objective function has the highest amount of elitism, indicating its higher chance to be present in the next generation. Therefore, chromosomes with a higher degree of fitness will have a better chance of reproduction and survival. In the selection process, elite chromosomes are selected from the crowd as the parents, after which new chromosomes called offspring are produced during the crossover process. If populations from the reproduction process provide inadequate solutions from the previous stage, the worst chromosomes from the new population will be replaced by the fittest chromosomes from the previous population. This process is repeated until the optimum solution is obtained based on the convergence criterion. The use of mutation operators is another common step in the operation of genetic algorithms, leading to population evolution for the next generation. This operator results in a better search of the design space. It also enhances the capability of the GA to find optimum solutions and generate features on the parent chromosomes that were not present before.

One of the most prominent advantages of GA is parallel search, facilitating the solution of large and nonlinear problems by GA. Hence, the GA can be a suitable option to develop a simple and useful computational model that has dynamic properties close to the real behavior of the offshore platform structures. If the probability selection rules are used in GA, probable solutions will be generated, which increase the convergence speed. A series of input parameters such as the number of elements, geometry of the structure, and the range of changes in the modulus of elasticity is determined and defined in GA.

Numerical modeling has been performed in OpenSees software in the present study. Then, the specifications of the reduction model are entered into MATLAB software to continue calculations. MATLAB software assigns different modulus of elasticities to sections using the genetic algorithm. In the process of genetic algorithm, populations are formed one by one and change into a generation, which has around ten populations. Each of these populations includes a series of modulus of elasticity assigned to all members. Then, the first population produces the modulus of elasticity according to the number of elements. A reduced number is assigned to the model in the next step, after which modal analysis is performed. The natural periods obtained from the reduction numerical model are compared with the natural periods taken from the actual structure (the physical model), and the difference between natural numerical and laboratory periods is calculated. If the difference between the natural numerical and laboratory periods is far from zero, the second population of the first generation is examined again, and so on. The second population also includes a series of different modulus of elasticity reassigned to the elements, and then the modal analysis is performed and the differences of the periods are recorded again. This process is constantly iterated and performed step by step to ultimately examine the tenth population. When examination of the populations is completed, each population (modulus of elasticity) is ranked. After ranking, the higher ranks have a higher probability of selection. In other words, lower differences are assigned the first ranks. The population with a lower difference between its natural period and the natural period of the real structure (laboratory model) is selected. These populations are selected in pairs to continue the problem solution. Next, a new offspring is generated by reproduction. In other words, the genes are combined to form a new population. Eq. (16), shows the strategy used to produce the next generation's population (i.e., chromosomes involved in the reproduction process). The success of the GA depends on the optimal solution of this stage. Besides, Eq. (17), is used to calculate the number of chromosomes involved in the mutation process:

$$n_c = p_c n_c = 2*\left[\frac{p_c n_p}{2}\right] \quad (16)$$

$$n_m = \left[p_m * n_p\right] \quad (17)$$

In which, n_c is number of chromosomes involved in the crossover manner. Where, p_c is percentage of crossover (percentage of chromosomes preoccupied in the crossover process); n_p presents number of chromosomes of each generation (population of each generation); n_m presents number of chromosomes involved in the mutation process and p_m indicates percentage of mutation (percentage of chromosomes involved in the mutation process, which is usually (0.2%-0.3%).

A number of n_c chromosomes from the current generation are selected as the parent chromosomes for the crossover process, resulting in two offspring chromosomes. The second generation is formed like the first generation. This process, which includes assignment of each population to the analytical model is repeated, and the superior populations continue reproduction, leading to better offspring. These superior offspring are continuously reproduced and form next generations until the optimal amount is ultimately achieved after 100 to 200 generations. According to Eq. (17), a number of n_m chromosomes are selected from the current generation for the mutation process, leading to n_m mutant chromosomes. Then, a number of n_p chromosomes with better fitness are selected as the sum of chromosomes of the next generation from $n_p + n_m + n_c$ chromosomes (sum of chromosomes of the current generation, chromosomes resulting from the reproduction, and chromosomes resulting from mutation). Therefore, Eq. (18), calculates the sum of chromosomes for the next generation:

$$p(t+1) = \text{the best } n_p \text{chromosome} \in \{p(t), c(t), m(t)\} \quad (18)$$

In which, $p(t)$, is sum of chromosomes of the current generation. Where, $c(t)$ presents sum of chromosomes resulting from reproduction and $m(t)$ indicates sum of chromosomes resulting from mutation process. If the series of calculated modulus of elasticity's are used instead of analytical modulus of elasticities, and then the modal analysis is performed, the resulting natural (new) period will be numerically closer to the natural period of the real (laboratory) structure. As mentioned, the reduction model is updated using the genetic algorithm process in MATLAB and OpenSees software. Therefore, the main purpose of the present study is to model and simultaneously update a reduction numerical model based on the dynamic information obtained from the laboratory model. Consequently, the modal parameters of the analytical model are very close to or match the parameters of the laboratory model specifications based on the proposed method in this paper. The present study has used GA according to the following flowchart (Figure 5).

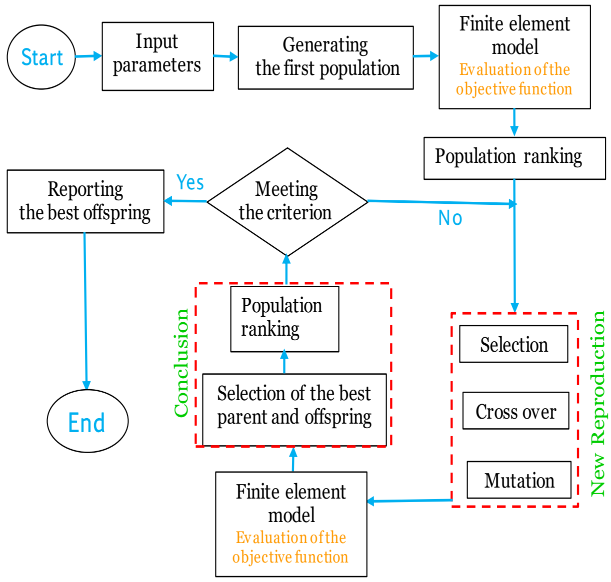

Figure 5- Flowchart of GA

The optimization model has the main factors including the decision variable, objective function, limits, or arbitrary constraints of the problem. Optimization is used when there is a decision-making challenge. Accordingly, the best decision is made using the optimization method when there are multiple decisions. In fact, optimization aims to find the best acceptable solution according to the constraints and requirements of the problem. In this research, natural periods are extracted from the offshore platform structure, and numerical modeling is prepared in OpenSees and MATLAB software. Therefore, it is possible to express the objective function based on the difference between numerical natural periods calculated by the GA and laboratory natural periods according to Eq. (19):

$$CF = \sqrt{\sum_{i=1}^{n} (T_i^E - T_i^A)^2} \quad (19)$$

In which, T_i^E is the laboratory natural periods of offshore jacket platform. T_i^A is the calculated natural periods and n presents the number of natural periods equal to 4 in this study. If the values of the objective function approach zero, the specifications of the reduction analytical model match the specifications of the laboratory model. In other words, minimization of the *CF* objective function makes the discrepancy between the reduction numerical model and the laboratory model minimal and close to zero. The methodology and study process are presented in Figure 6.

4. Results and discussion

4.1. laboratory-scale model and vibration experiment

The refining of the primary model is necessary to minimize the numerical model error according to the empirical signatures. Vibration signals of real platform structure are utilized to refining the FE model and minimizing the disparities between the natural periods of the finite element model and real structural system. Empirical modal test is recognized simply as a procedure for describing a structure in terms of its dynamic properties, such as periods, damping and mode shapes. Modal test is basically the study of the natural features of a structure.

In the current research, vibration experiments are carried out on the laboratory-scale model. A scaled 2D steel frame of a real jacket platform is employed to develop a facilitated model based on recorded modal features. This jacket structure is newly designed and installed in the Persian Gulf. Because of restrictions of the laboratory facilities and pipes availability, the geometric scale is considered as 1:65. The tested model, which involves of 17 nodes and 31 elements, and the initial numerical model of the scaled jacket structure is given in Figure 7. The geometric dimensions and element types of the platform are presented in Table 1 and 2. Since the tested platform model is fabricated from steel, the Young's modulus, density and Poisson's ratio of all elements are taken as $207GPa$, 7850 $\frac{kg}{m^3}$ and 0.3 respectively. In this paper, the experimental modal test is used to extract the modal features. The empirical 2D frame structure and instruments utilized for laboratory vibration experiment are also

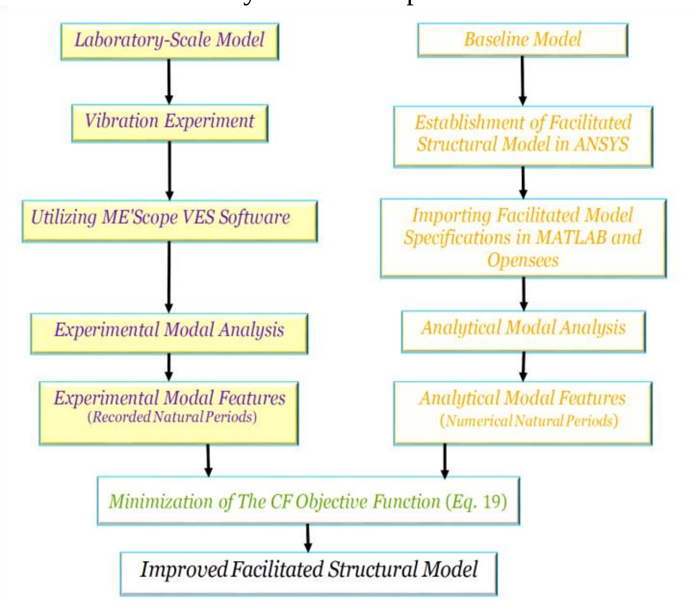

Figure 6- The methodology and study process

Table 1- The main characteristics of the model

Element	Element Type	Dimension (mm)
Columns	steel tube	34 × 3.5
Brace	steel tube	21 × 2
Topside	box cross-section	40 × 20 × 2

Table 2- specifications of the sections

specifications of the non-reduction sections	specifications of the reduction model sections
PIPE 21*2.0 mm	PIPE 11*1.0 mm
PIPE 34*3.5 mm	PIPE 21*2.0 mm
TUBE 40*20*2.0 mm	TUBE 20*10*2.0 mm

shown in Figure 8.

Fifteen uni-axial accelerometers are placed at the beam-column joints of the model to measure translational displacements in X and Y directions. The experimental model is excited by an electro-dynamic irritant (type 4809) with a force sensor (AC20, APTech) to gain structure response driven by a power booster (model 2706) all made by Bruel & Kjaer company. The white noise signal is applied to irritant the tested platform model. The frequency range and frequency sampling of the test are taken as 0–800 (Hz) and 16.385 kHz, respectively. More details on this vibration experiment are presented in Hosseinlou (2021). The ME'scope software is employed to gain the laboratory modal features by multinomial curve fitting of the frequency response functions (FRFs). The information required for computing the FRFs are recorded by sensors that are fixed on the physical model joints (See Figure 8). FEA of the scaled jacket models are accomplished establishing ANSYS and MATLAB program.

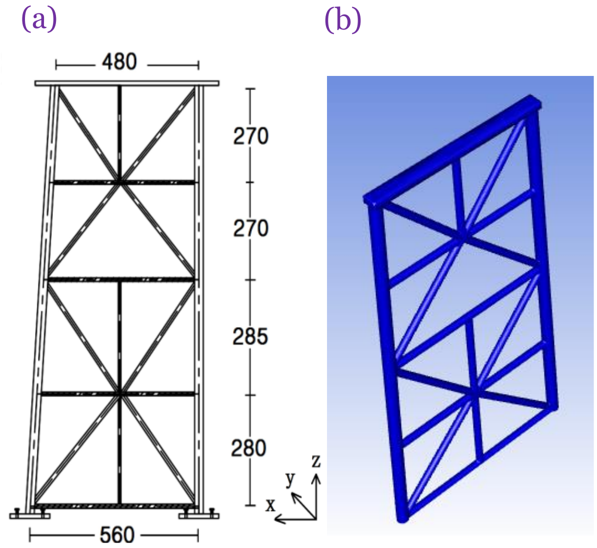

Figure 7- Sketch of the offshore structure: (a) 1:65 scaled model (b) Initial numerical model

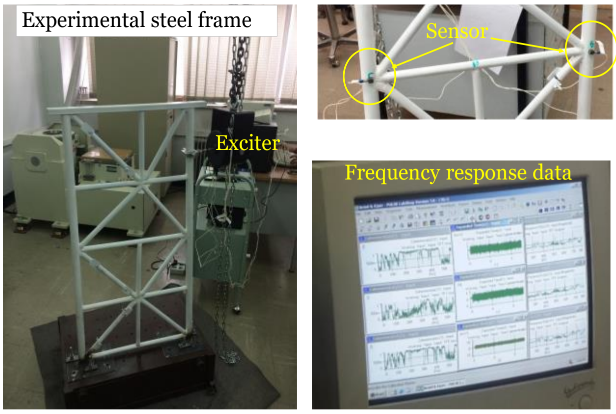

Figure 8- Tested physical model and instrument utilized in testing

The first analytical and experimental modal shapes of initial jacket model appear in Figure 9. Although the recorded natural periods of the first four experimental modal shapes is given in Table 3. The deformable shapes of the jacket platform model are also shown in Figure 10.

Table 3- Recorded natural periods (s)

Modes	1st	2st	3st	4st
Natural periods	0.102	0.022	0.013	0.0068

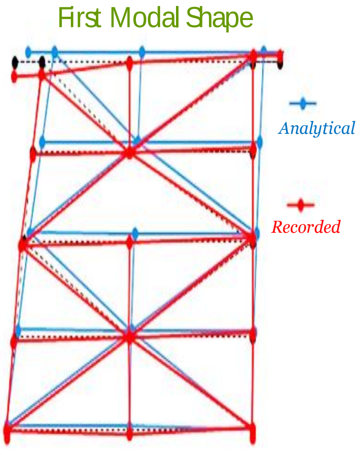

Figure 9- The first modal shape

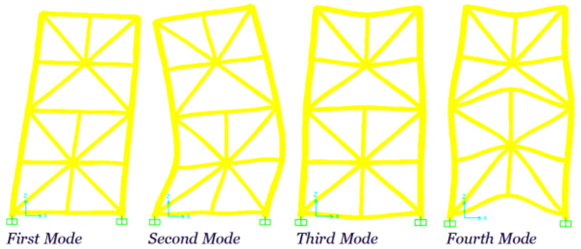

Figure 10- The deformable shapes of the jacket platform model

4.2. Improvement of facilitated structural model

The FEA is applied generally to simulate the structure numerically to gain modal features. Complex FEA systems have newly been available for structural analysis, however, there are three key challenges in applying FE models. Firstly, the applied application often indications a considerable discrepancy between mathematical calculation and laboratory results because they depend on prior numerical models that are often significantly uncertain and not confirmed with experimental modal data. Secondly, the computer models for structural analysis come with errors and uncertainty. Thirdly, another challenge in structural analysis is the higher degrees of freedom and multiplicity of components of the FE model. Ideally the more comprehensive and more sophisticated are the models, the more accurate the calculation results are expected. But these sophisticated models are not easily accomplished and suitable in practice due to their low computational efficiency.

Hence, the current researchers still select facilitated structural model in which a reasonable degree of exactitude could be attained. This study deals with such an improved facilitated structural model for offshore platforms. Based on the MDS scheme, the facilitated structural model is prepared in the MATLAB and ANSYS software's. also, the Young's modulus, density and Poisson's ratio of all elements are taken as $2 \times 10^{11} kg/cm^2$, $7850\ \frac{kg}{m^3}$ and 0.3 respectively, and the type of element used in the joint of pipe and linear. The schematic sketch of the sections of the facilitated platform model is presented in Figure 7 The stresses of the initial platform model and facilitated platform model are calculated for a concentrated force acting at the top of the platform as shown in Figures 11 and 12. According to the Von Mises stress contours obtained by the ANSYS software, In general response and the stress changes will be similar to Figures 11 and 12. As the results indicated, there is a good accordance between the dynamic behavior of the initial model and facilitated model.

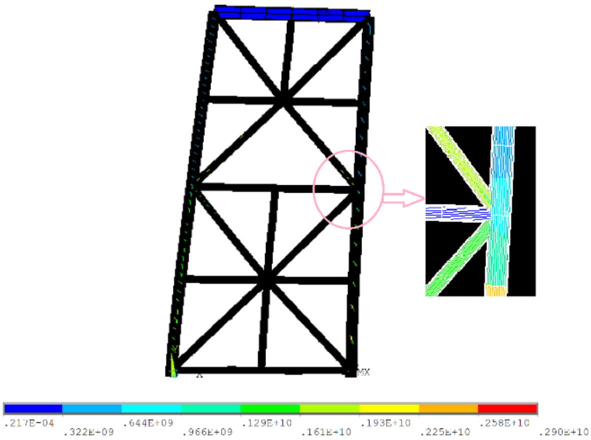

Figure 11- The stresses of the initial model

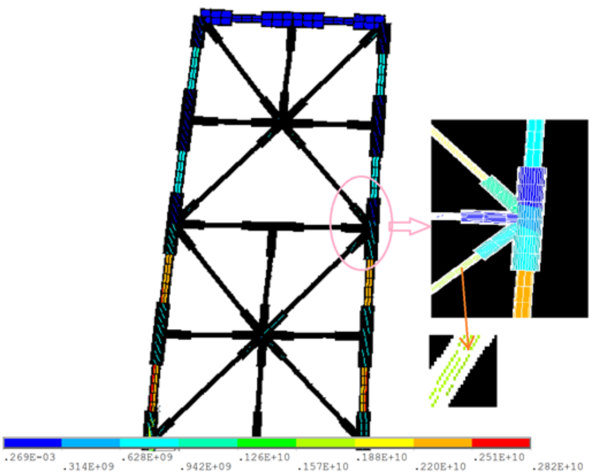

Figure 12- The stresses of the facilitated model

Based on the predetermined purpose of this article, Figure 13 shows the convergence diagram related to the process of updating and improving the facilitated model. In this diagram, the horizontal axis shows the set of generations and the vertical axis shows the objective function.

It is observed that with increasingly the number of generations, the objective function decreases. In other words, the chromosomes of each generation constantly build a new numerical model and then compare it with the laboratory model (According to Equation 19), and at each stage the objective function tends to the best answers. Finally, by converging the graph and minimization of the objective function, the differences between the natural periods of the laboratory model and the numerical model are minimized. For production of perfect improved facilitated structural model, the gained result from solving Equation (19) is presented in Figure 13.
The output obtained from MATLAB software for the modulus of elasticities of the improved facilitated model and assigning them to the numbered elements is reported in Figure14. Natural periods of the improved facilitated model and experimental model are listed in Table 4. Figure 15 also compares the natural periods of the models. It is observed that natural periods have very little difference so that this difference is reasonable.

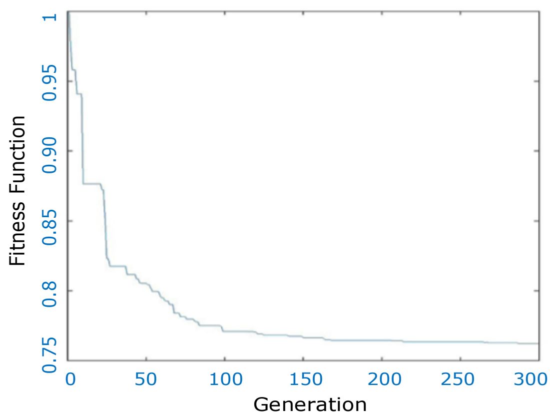

Figure 13- The convergence process gained from the solution of the objective function.

Table 4- Natural periods of the improved facilitated model and experimental model

N0	Natural Periods: Experimental	Natural Periods: Improved Facilitated Model	Dif. (%)
1	0.102	0.0986660435417491	3.2
2	0.022	0.0207617399150345	5.6
3	0.013	0.0118676908703218	8.7
4	0.0068	0.0064978588674736	4.4

Elements	E (N/m^2)
1	321000000
2	1817229567
3	1805945583
4	1719231676
5	1517610718
6	321000000
7	1743516620
8	1798315406
9	1818068583
10	1746391281
11	1818020296
12	1819000000
13	1695249287
14	1818973176
15	321000000
16	1814252333
17	1819000000
18	508924272.8
19	1819000000
20	321000000
21	1819000000
22	1819000000
23	769565576.7
24	1342100190
25	1805130615
26	1819000000
27	1819000000
28	1779726135
29	1819000000
30	1728580679
31	1809398990

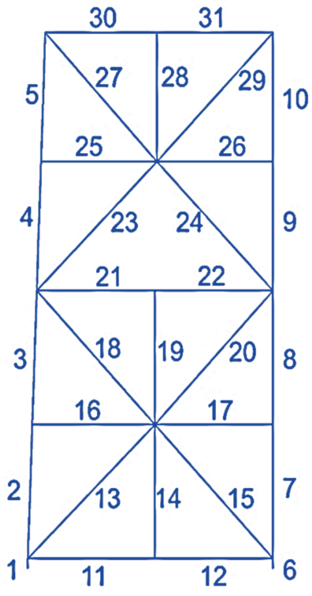

Figure 14- The output obtained from MATLAB software for the modulus of elasticity's

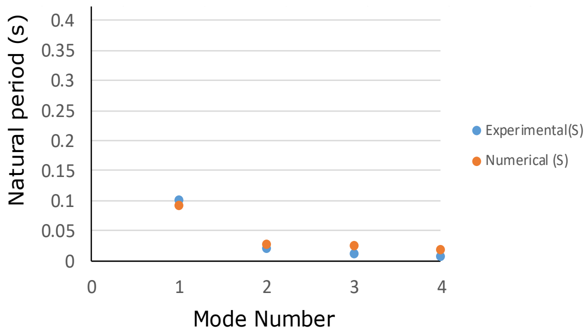

Figure 15- Comparison of the natural periods of the improved facilitated model and laboratory model

5. Conclusions

The main purpose of this work is to sketch an efficient modelling of complete framed jacket structures to address the considerable cost savings for each analysis or the ability to run larger analyses. In this regard, experimental modal analysis is performed on a physical model of an offshore jacket platform to improve a numerically facilitated finite element model.
Some differences between mathematically and experimentally obtained features appear because of various uncertainties in the FE-model and recorded modal data. To minimize these differences, facilitated model is refined based on the empirical data. The reflectance of the uncertainty effects on the simplified results has been employed as a prospect for this article for refining a facilitated Jacket platform model which is less sensitive to uncertainties arising from mathematical modeling.

The dynamical behavior of the jacket platforms is a combination of many properties including suppositions in the design criteria and construction, uncertainties in geometrical and material characteristics or some modeling uncertainties. The proposed scheme simplifies and provides rapid redesign of jacket platforms without having to rebuild the initial model from the start.

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