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A New Tool For Analysis of HPC Concrete Beam Under Static and Cyclic Loading Using Matlab

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Abstract

Use of high strength composites for bridges and decks of offshore structures are steadily increasing. Since these structures are subjected to fatigue loading, their performances under this loading needs to be evaluated. The trend in the load-deflection curve of the High Performance Concrete beam shows a similar trend of the load- deflection curve under static loading of the reinforced concrete beams. The strain energy absorbed by the beam was compared with that of the area enclosed below the load- deflection curve. It was observed that the area included below the load- deflection curve is same as the calculated strain energy absorbed by the beam. Another beam was tested under cyclic load separately. It was observed that the deflections of the beam increased with the number of cycles. The modelling and simulation of mechanics has become more popular. Comparing the results from simulated structural items either with experimental results or with mathematical results has become a regular practice. Creating the actual experimental situation by considering all the constraints the modelling will be done to get the parameters like deformations, strains, crack width, crack length, first crack load, first crack cycle and deflection at failure. Till date more researchers compared the Ansys modelling of the beam either with mathematical results or to the experimental results. The attempt was made in this work to get more accurate and more reliable results anew tool is used. This paper presents in detail the simulation of the beam for both static and cyclic loading using MATLAB-SIMULINK environment. The actual experimental investigations conducted on beams and compared with the results from simulated beam and pertinent conclusions were drawn therefrom are also presented.

Key words: Static and cyclic loading, Matlab- Simulink model, deflection, load-deflection.

Introduction

Concrete is a composite construction material. After the addition of reinforcement to the concrete the load carrying capacity of the beam is increased as the reinforcement steel is able to resist the tensile stresses in concrete induced by the application of the loading. High grades of concrete are becoming a preferable composite material for the engineers in designing the infrastructures, offshore platforms, coastal structures, high rise buildings, stadia, shopping malls, etc. At low load levels also the initiation of cracks and propagation of the cracks is due to the cyclic loading with the number of load cycles in the offshore structures. The fatigue loading is detrimental or degradation the performance of such structures and consequential catastrophic failure. More research on RC beams with regard to its behaviour under different types of loadings has been carried out and well documented. However, not much progress in research has been made with regard to the behaviour of HPC beams under fatigue loading.

Using the admixtures like zeolite, fly ash, and silica fume with partial replacement for Portland cement to the extent of 5%, 10%, 15% and 30% with a w/c ratio of 0.27 to 0.45. High Performance Concrete was prepared besides coarse aggregate, fine aggregate and super plasticizer. The 28 day characteristic strength was achieved ranges from 103.8 MPa to 114.7 MP. [1]. Using ultra fine fly ash and silica fume to the extent of 15% as partial replacement for cement and 0.5% of super plasticizer to the weight of the cement for making the High performance concrete better characteristic strength was achieved than that of the concrete with only ultra-fine fly ash. [2]. HPC was analysed for its pore structure and micro hard to compare the compressive strength and flexural strength of all the concretes. By considering the cost of the materials in different counties the optimum proportions of concrete mixes were arrived. By considering the parameters like shrinkage, curing, super plasticizer with cement the place and time to use concrete was discussed. To get the required cylinder strengths for some countries specific proportions were proposed [3]. The minimum void ratio method was used for designing the high performance concrete with the replacement of cement with slag and silica fumes partially and 15% of sand with fly ash. For compressive stress, splitting and flexural strengths of HPC specimens the stress curves were drawn. The curves indicated that the experimental concretes had better pastes to void ratios than a control batches ratio, i.e., N =Volume of paste/Volume of voids = 1.3. The results indicate that chemical strength effect and the physical packing effect can be achieved by using pozzolanic material. The compressive stress curves may keep increasing as the concrete ages[4]. Considering the concept of accumulated damage the hysteretic model was developed. The behaviour of reinforced concrete structures subjected to fatigue loading was predicted using the damage concept. Under cyclic loading the compressive strength of concrete inversely proportional to the intensity of repeated loading and the number of cycles[5]. The failure of RC beam is controlled by the fatigue failure of steel reinforcement if the cyclic stress of reinforcing steel is higher than its allowable fatigue stress. [6] . The increase in deflection and crack width for reinforced concrete beams were predicted based on the information on the fatigue properties of the plain cement concrete, reinforced concrete beams and the ACI design methodology for static loading. The analytical model is used to perform a parametric study, and is compared with the CEB-FIP code equation and some available experimental data. [7]

Artificial Neural Networks (ANNs) are used to develop an efficient method for finite element model (FEM) updating of reinforced concrete (RC) T-beam bridges. The finite element model of a sample bridge selected from Pennsylvania's bridge population is calibrated using neural networks trained according to datasets generated from linear and nonlinear analyses separately. The simulated responses obtained from calibrated FE models are compared to the field-measured responses of the bridge to quantify the accuracy of parameter estimation and the success of the model updating process. The study also indicates the significance of the non-linear response analysis for parameter identification for RC bridges, and underlines that the only consideration of dynamic responses for model updating may lead to erroneous parameter predictions, especially when the calibration is based on linear bridge responses. [8]. Simulation of the nonlinear seismic response to the multi-storied shear-type model and the member model based on the SIMULINK are established, the results of two examples show that the simulation of structural nonlinear seismic responses based on SIMULINK is available and reliable [9] The ultimate shear strength of RC deep beams using the artificial network was predicted The results developed from ANN are more accurate than by ACI code and strut and tie method [10]. ANN for shear strength of steel fiber reinforced concrete(SFRC) beam was developed and found that the accuracy of the network resulted in increase with the increase in the number of inputs. It was found that five input network predicts shear strength more closely than four-input networks. The accuracy of the results was found not biased with concrete strength, shear span-to-depth ratio, and beam depth. [11].

System Description

Under four point bending, experimental investigations were carried out in the reinforced High Performance Concrete (HPC) beams of size 150 mm × 250 mm × 3000 mm for both static and fatigue loading. The trend of the load-deflection curve under static loading was studied. The strain energy absorbed by the beam was calculated. Other beam was tested under cyclic load separately. It was observed that the deflection, compressive strain, tensile strain of the beams increase with the number of cycles. Table.1 shows the details and description of beams. Figure.1 shows the schematic diagram of the reinforcement details of the beam

Software Implementation

Sim Mechanics and Simulink combine to form an efficient tool for simulating rigid-body mechanical systems, especially in control systems applications. These products also enable us to simulate flexible body motion—a frequent requirement in aerospace, automotive, civil engineering, and other industries. Because the SimMechanics Body block represents only a rigid body, we must first transform our continuous flexible body into an approximate form that can be represented in Simulink. Sim Mechanics can then simulate flexibility with a fidelity that is sufficient for many applications, such as control design.

With the help of Simscape tools in MATLAB-SIMLINK the proposed construction of a base unit has modelled. The beam has been connected using rigid transformation block. The support hinges have been attached using connect joint/ weld joint.The rollers have been attached with the help of rigid transformation. Inertia and density of the beam calculated from the geometry of the beam. The beam has considered as a rigid model. The Lord has been attached to the beam. Similarly spreader beam and the test beam were attached. The structure for implementing static and cyclic load applied in the above description, model using inertia and external force block. The simulation in done under the following conditions. The environment is generated by considering as moisture loss, windless and with gravity of 9.81N. Considering the gravity force and inertia, self weight will be generated automatically in the proposed model from the density parameter. This model can be applied for different compositions of the concrete, hence can be used universally for different beam propositions to arrive properties like crack propagation, moment curvature, deflection of the beam and strains.

Results

Fig 2. Shows the Matlab Simulink model of the proposed beam structure, which has been done with the help of Simscape environment. Fig 3. Shows this 3D model rendered by Matlab, Simulink environment. Results are shown in Fig 4&5.Fig.4 gives the comparative load - deflection curve of the beam model and Fig 6 shows the cycle-deflection curve of the beam model compared with realtime experimental results. Results show that the obtained simulation responses close to that of experimental results..

Conclusions

From the results it is observed that, the model is similar to that of real time parameter. So the proposed model can be applied to various static and cyclic loading conditions for different composite concrete beams which reduces the time and cost of real time implementation. Further, this model can also be applied to obtain the crack depth, stress-strain of the beam and furthermore.

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Table 1: Beam Details

Compression Reinforcement		**Tensile Reinforcement**		**Shear Reinforcement - Stirrups**	
Size	**Number**	**Size**	**Number**	**Size**	**Spacing**
10 mm diameter	2	12 mm diameter	2	8 mm diameter	150 mm

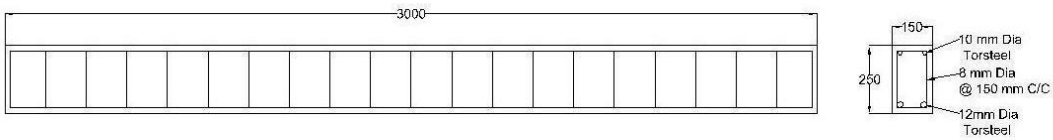

Figure 1: Schematic representation of Reinforcement details of the beams

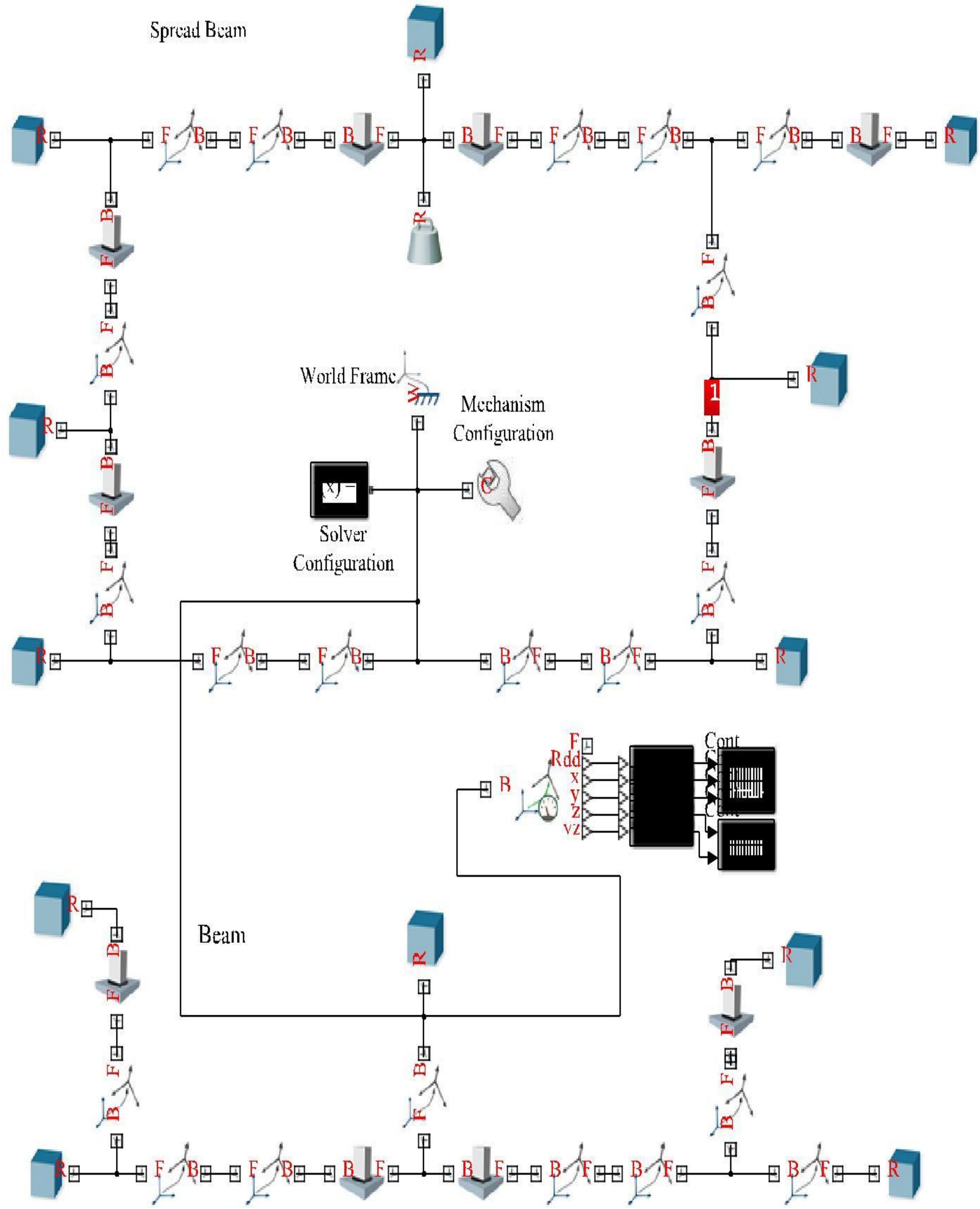

Figure 2: Matlab - Simulink Schematic representation of Reinforcement details of the beams

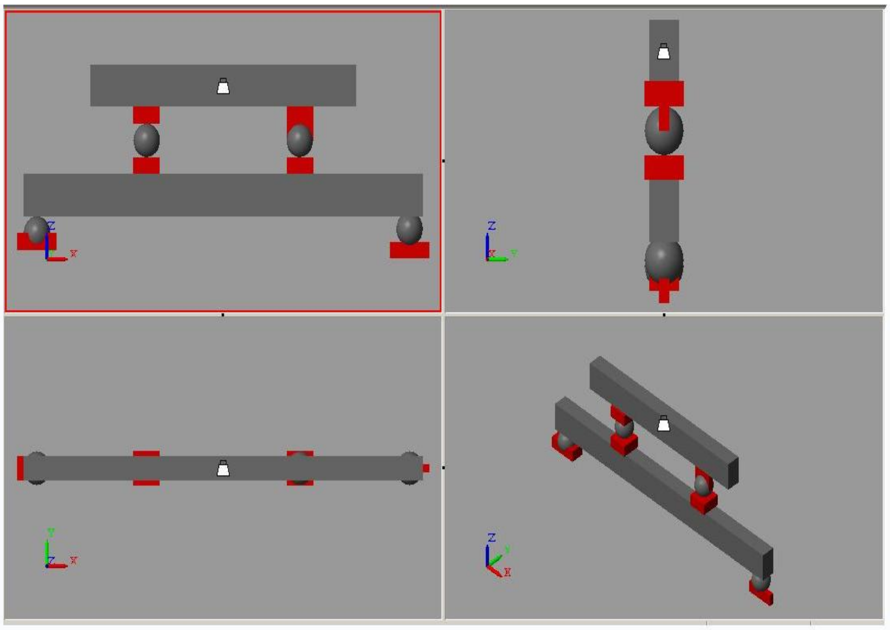

Figure 3: Rendered multiple view (front, top, side & perspective) proposed model

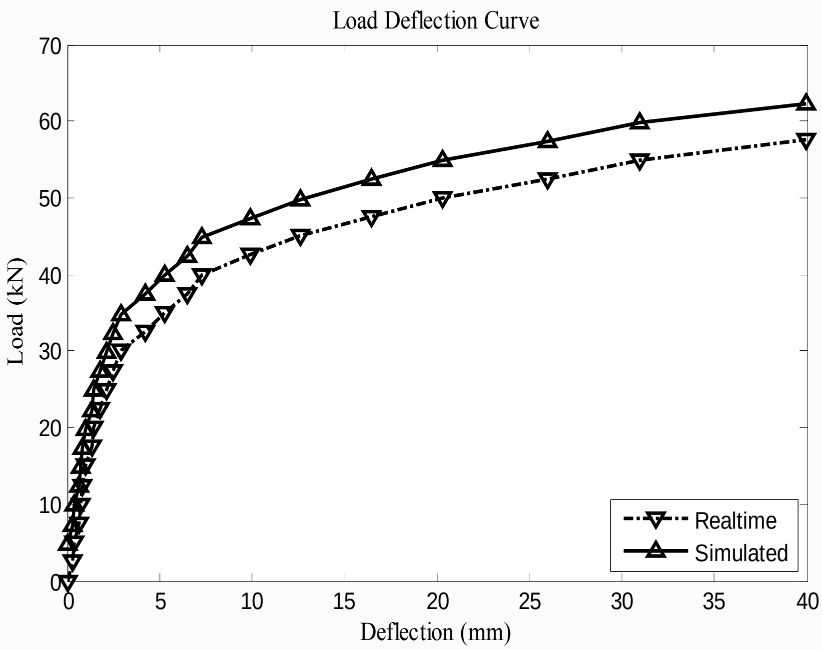

Figure 4: Load-Deflection curves for static loading

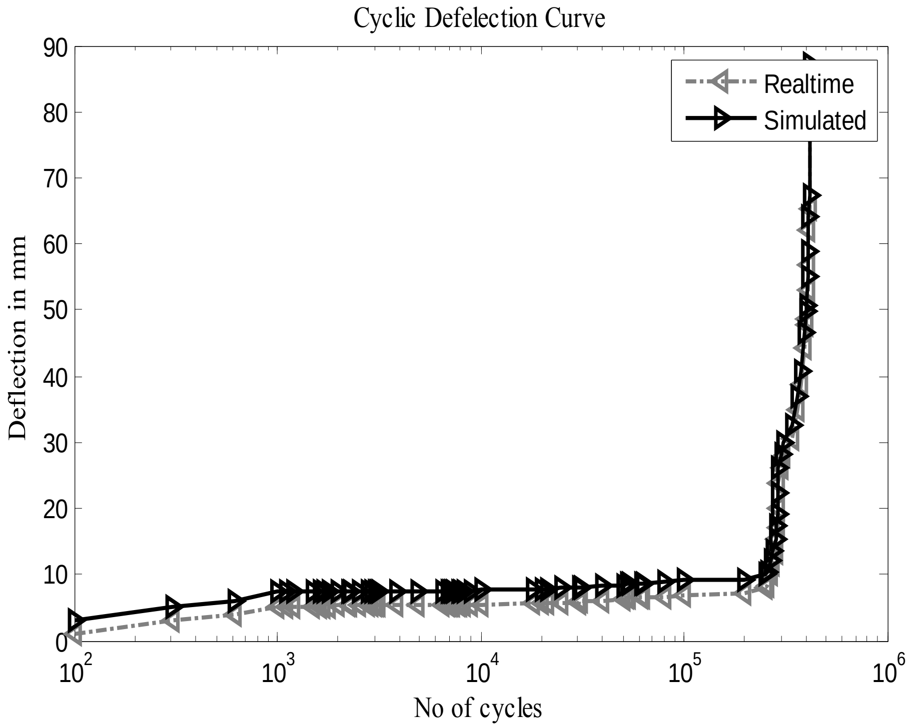

Figure 5: Cycle-Deflection curves for Cyclic loading