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IMPACT OF BENDING CRACKS ON CREATING STATIC AND VIBRATION CHANGES IN REINFORCED CONCRETE BEAMS

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ABSTRACT

Construction industry in view of capital and volume of human resources is the biggest industry the country. The rapid growth of population and demand increase requires decreasing the delivery of project time and decreasing the return time of investors' capital have caused that the necessary of revolution in the traditional method of construction industry will be increased. One of the main members of reinforced concrete structure is beam. The concrete beams by considering the high pressure resistance of concrete and reinforcing them by bending behavior are suitable. Although the compressive strength of the concrete is high, the tensile strength of concrete is so low and it is about 6-10 percent of the compressive resistance. The bending crack in fact occurred in the region that there is the negligible shear, therefor bending play the main role in the region. Considering the beams usually tolerate the bending stress and sustain more cracks more than the beam which has the significant axial forces simultaneous with its bending. The existence of the crack in the structures or engine ring parts cases the disorder in their performance. One of the suitable method in order to determine the crack recognition in the structure is studying the static and vibration behavior of the component in different time (during

the working time) and comparing them with the primary behaviors (without fault). In order to study the effects of crack on the vibration behavior of parts, the theoretical and experimental methods have been introduced. The present paper have been conducted with the aim of the effect of bending crack on creating the static and vibration changes of reinforced concrete beam. The obtained results of the study can be useful and practical especially in the damage of the structures.

Keywords: Reinforced concrete, static, vibration, bending crack

INTRODUCTION

By increasing the population and increase in the construction rate and also due to the limiting the resources and consumption materials, the demand for using the new and modern material have been increased in construction industry. The modern technology create the different method of the construction in building construction offers for the engineers, the correct analysis of the modern technology crated in the structures in one hand and familiarity with features of the material in other hand help the architectures and engineering of the building in order to reach the modern method of construction for finding the solutions of quality correction, quality enhancement of modern materials in the industry.

The new look to the construction method requires the use of new materials. Although it may possible the construction technology or execution method to use the materials is now uknown but recognition of the materials and their properties effectively help to create their requirement in the community. One of the biggest modern technologies in present century is Nano technology that its utilization is helpful to meet the requirements in building industries. In use of modern industrial in order to more efficiency is necessary to use the new materials and technologies of the building. Today, new materials can construction has the significant position and use of them offer many advantages in view of quality and quantity. The advantages of use of the technology can be referred to increase of material quality, economize in use of energy and economical cost effective to use energy and efficiency in the management of construction. Disregarding the standards in view of the construction due to complete non-introduction of the modern system and technology of building for most the engineers and also some of the architecture of building construction in the section of building cause the lake of determining the advantages and

disadvantage of each system for implementation. Building industry in view of capital and human resources is the biggest industry in the country. The rapid growth of population and increase of necessity requires to decrease the delivery time of civil projects and decrease of return time of investors' investment have cased that necessary of revolution in traditional method of building industry will be increase (barkchian, Ibrahimi Moqadam, & Hami, 2009).

Use of modern technology of building especially using the type of lightweight materials such as lightweight concrete types, composites, polypropylene and polystyrene) is in term of light weight and prefabricated construction and increase of system structures against earthquake. So, utilization of modern construction technology not only has the significant importance, but also creates the necessary of modern technology utilization in construction industry especially building construction.

Unavoidable occurrence of earthquake and impose losses of life and property, especially the detrimental earthquake which have been occurred on recent years in different region of world casus the necessary to find a suitable solution for inhibiting the natural phenomenon. Since the inhibition of earthquake occurrence is impossible, immunization of existence building to confront the natural phenomenon is an avoidable affair. On the other hand, technology development in all fields such as building and also the studies of engineering regarding the building behavior against earthquake provides the possibility to use the modern systems in retrofitting of existence structures (control, 2012). The new look to construction method demands the use of modern materials. Use of modern industrial system in order to more utilization is necessary to use the modern constructive materials and technologies (Ghorji bandpi, 2013). The modern technologies in construction requires more attempts of private and public units in order to provide the acceptation field of this type of technology in the society. Use of modern technology and observation of technical and scientific points with focused on the international laws causes to construct the building and speed in production.. Furthermore, retrofitting is called as a set of operations which is conducted on a section or structure of the building so that the structure can sustain the additional loads than its primary state and can show the best behavior. Seismic rehabilitation decrease the possibility of vulnerability during the earthquake in all elements of the building

both structure and non-structure (Jomhor, 2012). One of the main elements of the structure of reinforced concrete is beam. Concrete beams by considering the high pressure resistance and reinforcing them using steel bending behavior. Although the compressive strength of the concrete is high, the tensile strength of concrete is so low and it is about 6-10 percent of the compressive resistance (Mostofi nezhad, 2009).

The bending crack in fact occurred in the region that there is the negligible shear, therefor bending play the main role in the region. Considering the beams usually tolerate the bending stress and sustain more cracks more than the beam which has the significant axial forces simultaneous with its bending. Therefore, effective equally robustness ratio between these two elements is an error.

The performance concept in structure evaluation and design

The first step in evaluating and retrofitting the seismic structure is attention to structure importance and economic situation which should be selected as a suitable performance aim for the structure. After selection the building performance aim, it can be possible to meet the seismic behavior requirement for using in analysis and also the maximum vulnerability for using in design and evaluation of structural and non- structural system retrofitting.

For seismic strengths and evaluation of the structures is followed the following aims:

- In the intense earthquakes which may occurred during useful life of the structure it should be prevented from structure and non- structural damage.
- During the earthquake which sometimes occurs in useful life of the structure, the structural damages should be limited in order to preserve the personal life safety of the resistance.
- In the intensive earthquake which rarely is occurred during useful life of the earthquake it is prevented the complete collapse s of the structure (Rofooei, 2006).

Bending cracks

This type of crack is occurred where there are many forces in the tensile region or in the middle section of entrance. The beams which their cracks are bending are considered as the beams with shapeable behaviors. The bending cracks is occurred when bending strength of the cross- section of bending strength is low and tensile grain has the most width and convergence toward the other grains and it can occurred alone or

together. The crack affects the health of the structure and it rapidly should be considered.

The concretes are week against tensile, so many of the concrete structure under the service loading are cracked. The crack may be the visual vulnerable type or it may be damageful for structure life or it may be dangerous for vibrating structure.

The first crack is occurred when the weakest section reaches the tensile strength of the concrete.

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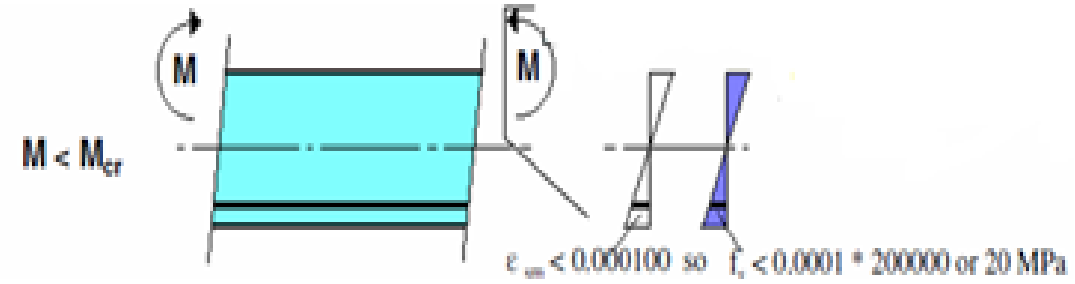

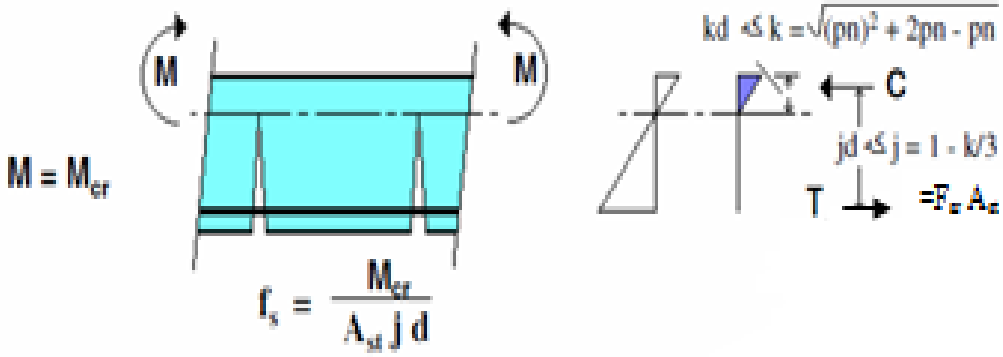

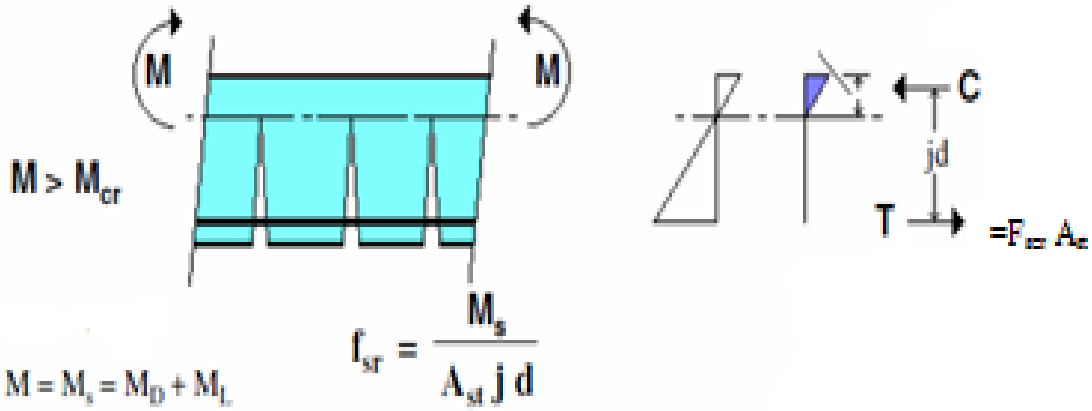

Figure 1: stress rate of beam in tensile members

Static loading

A concentrate static load at the midspan with the simple bearing situation has been used for creating the shear and bending cracks in the beams. The system has the low friction in the bearings and creates not only the maximum anchor in midspan, but also the equal shear forces throughout the beam. As the figure 2 shows, the concentrated load is transferred to a beam by a hydraulic jack. The force rate is recorded by a load cell, transducer, and strain gage and data logger.

Static loading is conducted step by step. In each step, load gradually is applied until the specific rate and in the next step, the load rate have been increased in order to achieve the beam in the collapse step. In each step after load applying, full unloading is done and the forces reaches to zero and displacement amount and inertia strain is recorded in the system. Use of the inertia transformation is the suitable solution for determining the cracking level of a beam after unloading instead since measurement of crack width is a difficult affair (Davodi, ghalami isfahani, & Mostavafian, 2009).

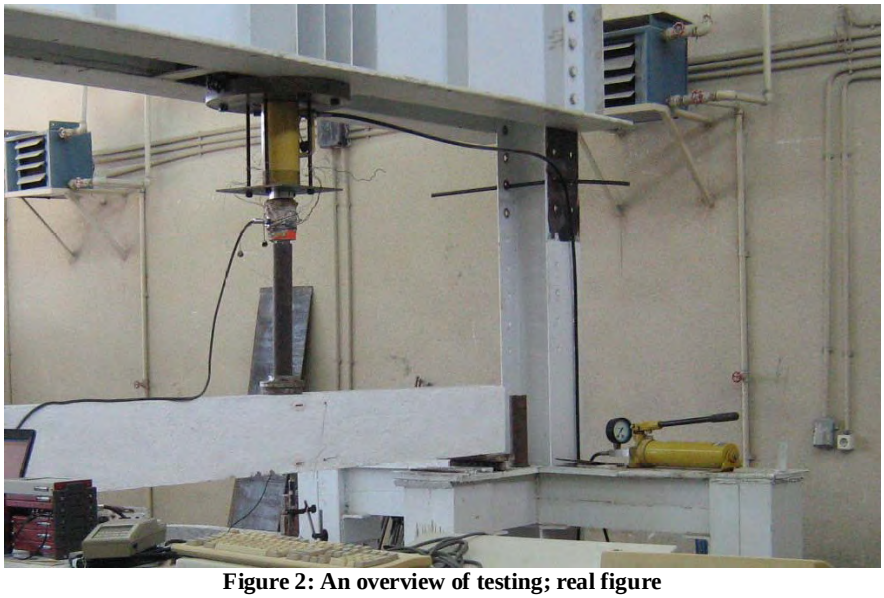

Figure 2: An overview of testing; real figure

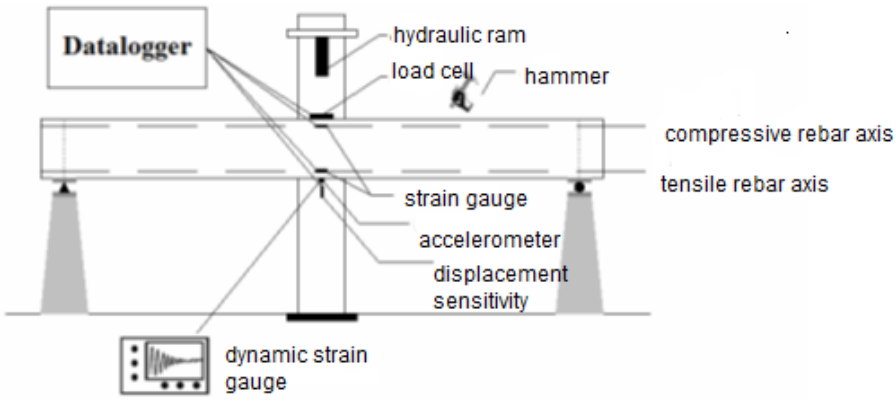

Figure 3: An overview of testing; schematic figure

Vibration behavior

The existence of crack in the structure or engineering sections causes their performance disruption. One of the suitable methods to determine the crack in the structures or components is to study the vibration behavior of the components in different time and compare it with its primary behaviors. In order to study the impact of crack on the vibration behaviors of the components, different theoretical and experimental methods have been introduced. One of the useful methods to use the specific cracked elements is the finite element model that is assumed a crack with certain dimensions in the element. Then, the finite element model dominant on the element is extracted by using the elastic tension around the crack. The utilization advantage of specific cracked elements than the common method of finite element analysis causes to decrease the freedom degree ad also less calculations. The mentioned method is a general method and using the method, it can be possible to obtain the stiffness matrix for each cracked element by having the necessary information of tension behaviors around the cracks. In general state, loading in direction of parallel to the crack can have the significant effect in the elastic strain energy rate and critical failure of cracked object. The effect depends on Piosson's ratio of the materials so that foe the materials with the specific range of Piosson's ratio, increase of parallel load with crack causes to increase critical failure and for the other range causes to decrease the critical failure of load. The range depends on the object's situation in view of plain stress and strain (ayat allah, Ahmadian, & allah, 2003).

Significant of the study

Building industry in view of capital and human forces is the biggest industry in the country. The rapid growth of population and demand increase requires decreasing the delivery time of architecture projects and returning time of capitalist have been causes that necessary to create the revolution in traditional industry of construction industry will be increased. Earthquake is the detrimental phenomenon that sustains a loss during recent half- century. Iran is considered as one of the earthquake- prone countries of world. Possibility of intense earthquake occurrence due to natural situation of earth in one hand and design and construction of concrete buildings which the regulation of loading have not been considered in the other hand causes that seismic evaluation is considered as one of the necessary requirements (ghodtari amiri, gholamreza tabar, & Razavian Amraii, 2008). Considering Iran places on one of the active seismic belt, creating the concrete structures secured with the optimal resistant to the weight has the significant priority. In the common buildings, execution of the structures especially designing with the developed instruments is not desired quality due to low wag of the workers and the other technical elements. Furthermore, all building experts is aware that industrialization is a security for enhancing the construction (Bandpi, 2013)

Constructing the secured buildings which meet the health, rest and economical requirements of person and society is the main aims of the building engineering. Choice of industrialization of building is as a systematic method to reach these aims. Achieving an option that not only observes the national regulation and technical criteria but also has the sufficient speed and accuracy is suitable for the requirements of the building (Jomhor, 2012).

LITERATURE REVIEW

Rahaii et al (2003) studies the effect of reinforced concrete foundations using the steel sheets against vertical components of the earthquake. In the study, two experimental and analytical methods have been represented regarding the effect of reinforcement of concrete bridge piers using the steel sheets against vertical components of earthquake. In the first stage, the experiment (push-up impact) has been conducted on the non- reinforced concrete bridge foundation using the reinforcement of the steel sheet with different weights and reinforcement with armature. In the second stage, use of finite element method of reinforced concrete bridge piers have ben modeled (Rahaii & Chini Forosh, 2002).

Ghodrati et al (2008) evaluated the performance behaviors of reinforced concrete frames with steel coaxial bracing using one of the seismic rehabilitation methods of concrete frames using steel bracing. In the present paper, some samples in the book of "standard frame 2800" have been modeled by using average formation which has been estimated for seismic loads. In order to evaluate the frames under the modified seismic loads, the models are based on the again seismic loading. Again analysis of the frames depicts that stress ratio in the most of the beams have exceeded more than one in seismic rehabilitation based on the book of "standard 2800- third edition". The reinforced frames by nonlinear static analysis coincidence with seismic rehabilitation regulations have been evaluated. Furthermore, the manner of plastic hinges formation and performance levels have been evaluated by the members. Displacement of plastic hinges and performance level has been defined based on the nonlinear modeling regulations inserted in the seismic rehabilitation instructions of existence buildings. The results of the study show that used method provides the possibility of seismic rehabilitation of frames in the threshold performance (ghodtari amiri, gholamreza tabar, & Razavian Amraii, 2008).

Shoshtari and Bayat (2009) in the study of seismic performance of reinforced concrete frames by FRP examined that one of the seismic rehabilitation of concrete structures is use of FRP cover in the area. Confinement of structure elements using FRP causes to increase the bearing capacity and also structural formations. When the concrete is confined using the type of cover, its behavior changes and its stress and strain curve which have been represented different models will be different. in the study, reinforced concrete frames which have been strengthened by FRP cover is modeled using finite element of Seismostruct software considering the various parameters such as plate thinness, kind, amount and form of confinement, compressive strength of concrete core and confined stress-strain model. In addition, the effect of amount and form of confinement on their seismic performances has been evaluated before and after their reinforcements.by studying and comparing the results of the analysis, it is seen that use of FRP cover causes to increase the structural reinforcement and rehabilitation, formation and load capacity of the structures and also decrease the maximum displacement over 50 percent which has the significant role to

decrees the detrimental effects of seismic loading (Shoshtari & Bayat, 2009).

Habibi in 2007 represented a method for optimal design of moment frame of reinforced concrete based on the performance considering two pattern containing rectangular patterns. In the study, it has been shown that it can possible to improve the structure performance under the each loading pattern (habibi, 2007).

Pampanin and Akguzel (2012) evaluated and designed a seismic resistance by FRP composite. In the study, an analytical method has been represented for evaluating the reinforced concrete and beam and column joint before and after the building repairs using flat polymer fiber. Leman et al (2013) have been studied the seismic behaviors of concrete walls. The present paper studies the reaction of correlated walls. The experiments have been conducted from 3 bottom floors of a 10- stories building. The inserted damages consists of correlated beams, frame walls, separated components of the walls. The experimental tests which create some damages have been conducted. The damages were due to concrete breaking, non- balance of longitudinal bars in the connected walls. The experimental results show that design of modules for the correlated wall system causes to improve the reinforcement of building (Akguzel).

Ghoji et al (2011) evaluates the moment steel frame formation especially for seismic retrofitting using yielding damper ADAS. In recent years, many attempts have been conducted in order to develop the energy consumption concept as an applicable technology for confronting the earthquake. One of the effective mechanisms has been conducted for energy consumption by non-elastic deformation of steel components. The aim of the study was to evaluate the ADAS steel damper performance, using them in retrofitting of the steel moment frame, evaluation of formation and energy consumption of the earthquakes imported in the steel buildings. In the present paper, three steel frames of 4, 8 and 12 regarding the week floor have been retrofitted using the ADAS dampers. In this regard, the necessary dampers for design and frame seismic performance have been evaluated using perform-3d software. furthermore, by applying the mapping velocity of Bam, Northridge, Elcentro, Naghan, Rudbar and Lamaperis earthquakes, it have been attempted to obtain the comprehensive results (Ghoji & Karami, 2011).

METHODOLOGY

Considering the specific behavior of concrete members and creation of crack and decrease of robustness of reinforced concrete beam under the reciprocating loads and concrete features, enhancement of the compressive and stretch strengths have been created. In ANSYS software, elements of SOLID45 and SOLID65 are the only elements which can be modeled the concrete components. SOLID45 element cannot analyze the cracking and smashing the concrete and also the modeling of the armature is not possible by it. Solid 65 elements is a 3d element that is used for modeling the concrete with or without rebar. The element also can model the concrete cracking in the tensional area. The element has been determined with 8 nodes which each node has three freedom degrees in direction of 3 orthogonal directions of X, Y, Z.

In the figure 4, an overview of the element has been shown. SOLOD65 element consists of both types of geometric and material nonlinear solutions. In the element, three desired direction can be defined a rebar.

For modeling the concrete beam, a Solid65 element was used. bending cracks in the reinforced concrete beam and static and vibration changes have been modeled, based on the figure 4, the relationship of load-displacement in a concrete member have been divided into three sections: non-cracked elastic stage, development stage of crack, concrete cracking stage.

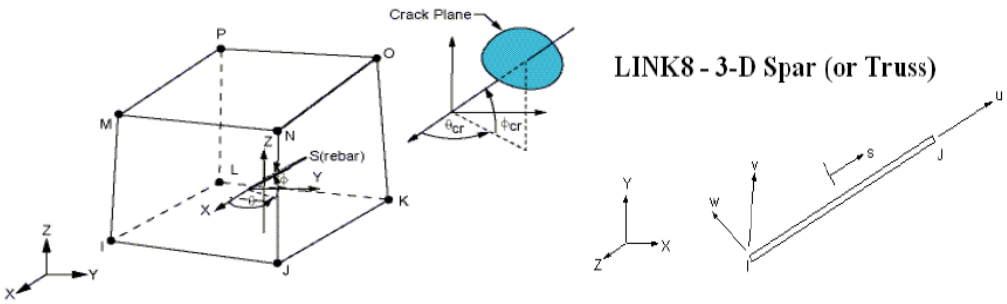

Figure 4: An overview of SOLID65 element characteristics and the manner of armature placement

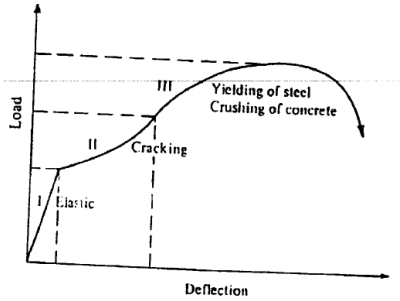

Figure 5: relationship of load- displacement for a member of reinforced concrete

In the study, a 4- stories building and with the plan of figure 5 have been used. The construction is considered as a residential building with filler block celling and computational dead load qD=600 kg/m2 and live load of stories qL=200 kg/m2 and the story height of 3m.

All structures have been commutated based on the Iran 519 regulations of loading and earthquake cutting force based on the 2800 regulation have been calculated by static method and it is considered in the design.

CONCLUSION

One of the criteria which are effective to determine the behavior of a reinforced concrete beam is creating the cracks. In other word, each type of cracking represents a kind of behavior. Considering the weakness of concrete in the strength area, there are three types of flexural cracking, shearing and shear in the flexural in a concrete beam. Therefore, one of the cases that can be as a foundation of study of the analysis is the conformity of a cracking model of a beam obtained from the analyses with the real cracking model in the laboratory. The present paper have ben conducted with the aim of the effect of bending cracks on creating static and vibration changes in reinforced concrete beams. The obtained results of the study have the special importance since it consist of two static and vibration changes. Having a model which has the most conformity with the reality is important to enhance the accuracy of the results for understanding the solution. One of the most important elements to access the accurate model is use of laboratory results and their conformities with analytical results which creation of static and vibration changes in reinforced concrete beams have been considered in the study considering the creation of a crack in the samples. The result of the study causes to determine a method for modeling the cracked concert beams. The study can be applied especially in evaluation of structure damages.

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