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SEISMIC RETROFITTING IN STEEL FRAME STRUCTURES BY DIFFERENT CABLE ROPE BRACING SYSTEMS

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Abstract: In the last two decades, several seismic retrofitting techniques for steel structures have been developed and practiced, but rarely validated with experiments and modeling. This research aims to develop a new and high-strength seismic retrofitting technique for steel structures. An innovative retrofitting technique with a cable system. Experimental results of steel frame structure retrofitted with cable system and cable system with square plate at the center are presented. The results showed that both the strength, stiffness, and ductility of tested specimens were significantly enhanced with this new technique. The large displacements and lack of sufficient lateral stiffness are the main problems of moment-resisting frames. The purpose of this study is to demonstrate the efficiency of the system, in which all cables have tensile forces under the seismic load and cables are not slackened. The behavior under different frequencies was investigated on ABAQUS software. Adding X- bracings & a steel plate in the center of bracings causes all cables to involve against the seismic load and all cables remain in tension Therefore, improves the performance of the structure against the applied seismic load.

Index Terms **- ABAQUS software, seismic retrofitting, steel plate in the center of bracings, stiffness of the frames, X- Bracings.**

I. INTRODUCTION

Steel framed structures are one of the most common construction types in India. Although the history of past earthquakes has shown that Steel framed buildings have suffered huge damage and also accounted for the maximum loss of life, they continue to be popular. Most historic or existing buildings need to improve their performance by retrofitting and strengthening to resist potential earthquake damages. Seismic rehabilitation of existing buildings is a difficult task. Several factors involved in rehabilitation are architectural constraints, the cost of possibly closing the building (or part of it), and the necessity of heavy equipment. Concentric bracings are worth considering as they are a simple and effective rehabilitation system, especially where story drifts should be limited. Bracing systems should be strong enough to resist seismic forces and yet light enough to guarantee the existing structural elements for further reinforcement. Additionally, these systems would be still more desirable if they are installed quickly without needing the evacuation of structures. The bracing system with tension–only elements such as cables can be installed easily. This system is effective in seismic rehabilitation due to its minimum requirement for site construction, no need for heavy equipment, and results in minimal environmental impact and noise. Cables are defined as flexible tension members with negligible resistance against bending. Cables with a high strength-to-weight ratio have a variety of applications in civil engineering. They are frequently used in bridges and large-span spatial structures; however, their application in the buildings has been limited. Some researchers have examined the application of cables in buildings. A wire rope bracing system with a central plate is a modern bracing system. The bracing members do not act for small and medium vibration amplitudes, while in the large ones they prevent unacceptable large story drift.

II. METHODOLOGY

Seismic analysis is conducted for frames by using Horizontal Shaking Machine and also on ABAQUS Software with the different parameters of comparisons i.e. frequency and displacement respectively.

MODEL ANALYSIS ON HORIZONTAL SHAKING MACHINE:-

For the analysis of the system here we are using Horizontal Shaking Machine and by using we are going to find out the frequency at which our models become unstable so that we can compare the most stable model among our 3 models as shown in Fig. 2.1, Fig.2.2, Fig.2.3, Fig.2.4, Fig.2.5, Fig.2.6, and Fig.2.7. The models are A (Typical MRF), B (RF with typical cable bracing), and C (MRF Center plate wire bracing).

(Fig.2.1) Horizontal Shaking Machine

(Fig2.2) Normal Frame – Stable condition

(Fig2.3) Normal Frame - Unstable Condition

(Fig2.4) Frame with x-wire bracing-Stable Condition

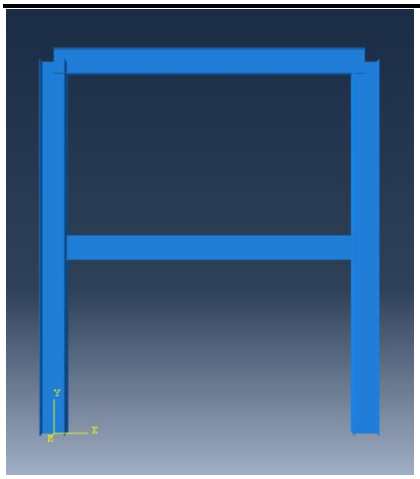
(Fig2.5) Frame with x-wire bracing-Unstable Condition

(fig2.6) Frame with Plate at Center Bracing – Stable Condition

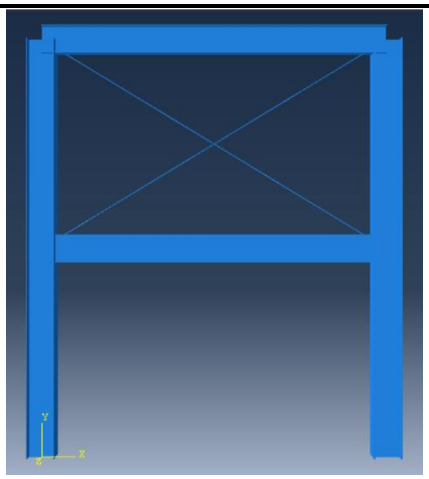
(fig2.7) Frame with Plate at Center Bracing Unstable Condition

MODEL ANALYSIS ON ABAQUS SOFTWARE: -

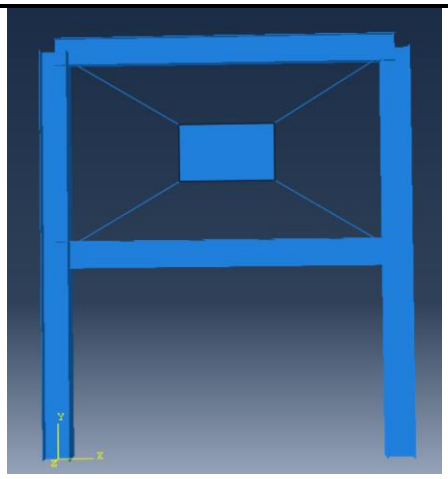
For the Seismic analysis of the system here, we are using ABAQUS Software with Time-History analysis data taken from the earthquake that happened on 06-11-1997 at Mont Chateau, West Virginia, United States. (Record Seq. 169) and by using this we are going to plot Displacement-Time Graph and find out at which our models become unstable with displacement at a different time so that we can compare the most stable model among our 3 models as shown in Fig. 3.1, Fig.3.2, Fig.3.3. The models are A (Typical MRF), B (MRF with typical cable bracing), and C (MRF Center plate wire bracing).



(fig.3.1) Normal Frame



(fig.3.2) Frame with X-wire bracing



(fig.3.3) frame with plate at center bracing

III. RESULTS AND DISCUSSION

Three different frame structures are analyzed. Firstly with Horizontal Shaking Machine, we started analyzing with zero frequency & increased till the model becomes unstable, and we got different results as shown in table 1 dynamically and the results obtained are graphically shown below.
Also, these three frame structures were analyzed on ABAQUS Software to determine the displacement of the member's w.r.t by plotting the Displacement-Time graphs. By these, we are able to find the most suitable retrofitting amongst three considered frame structure cases for experiment & study.

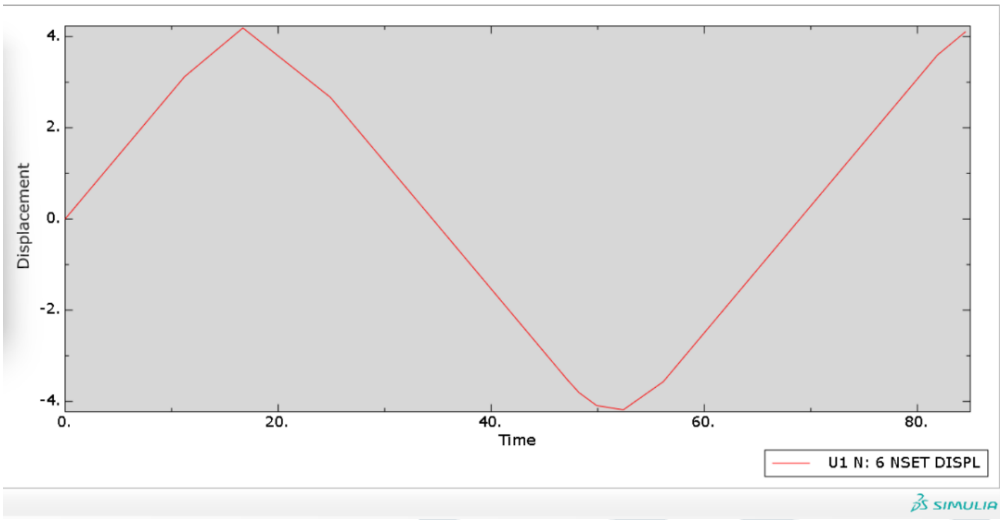
ANALYSIS RESULTS ON HORIZONTAL SHAKING MACHINE:-

Models	The frequency at which the model becomes unstable
Normal frame	7.5 Hz
Frame with x-wire bracing	11 Hz
Frame with plate at center bracing	9.5 Hz

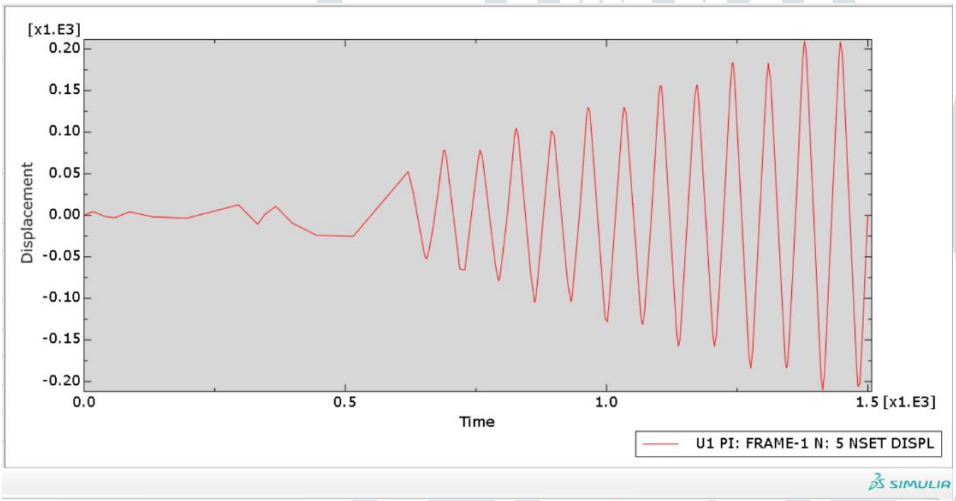
ANALYSIS RESULTS ON ABAQUS SOFTWARE:-

Three different frame structures are analyzed dynamically with Time-History Seismic analysis and the results are obtained as Displacement-Time graphs shown below: -
Displacement Shown by Normal frame is maximum & Frame with X-Wire Bracing is minimum amongst three cases.

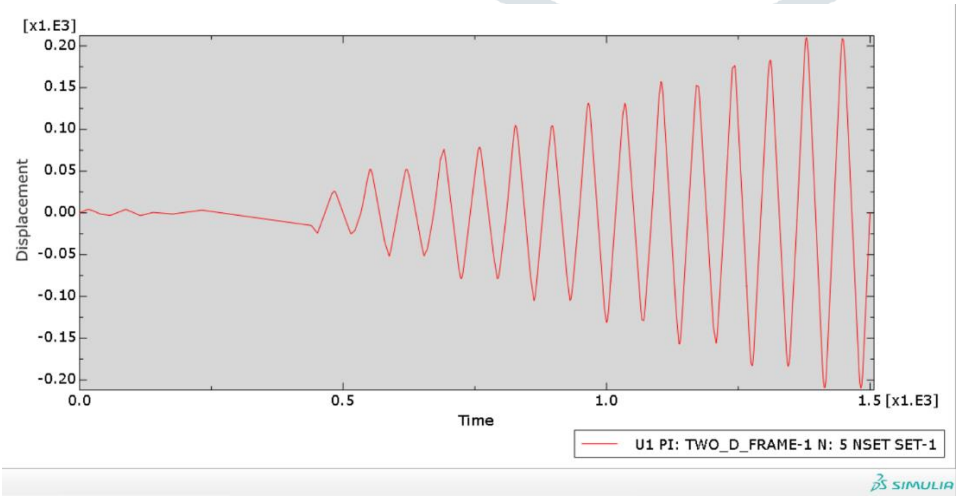
1– Displacement-Time curve for normal frame



2– DISPLACEMENT-TIME CURVE FOR FRAME WITH X-WIRE BRACING



3– Displacement-Time curve for frame with plate at center bracing



IV. CONCLUSION

This study described seismic retrofit methods for moment-resisting frames. The method adopts x-wire ropes & center steel plate with x-wire ropes as the bracing member to increase the stability of the structure. The cost of the material and installation process for both retrofitting methods is very less as compared to the cost of the structure. Amongst the two methods, the x-wire rope bracing system is the most suitable as shown in the results, and economical also due to less work as compared to center steel plate x-wire

bracing. Concerning all these advantages, x-wire & center plate with x-wire bracing is highly recommended in seismic strengthening and rehabilitation.

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