STUDY ON SEISMIC BEHAVIOR OF STEEL SLIT SHEAR WALLS USING ANSYS

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ABSTRACT:
Finding a suitable answer to a problem through a methodical procedure is whatresearch is. Structures can sustain serious damage from earthquakes. Thefoundation of the conventional seismic design approach has been to have enough ductility to sustain the applied loads. While life safety requirements are met, severe earthquakes are likely to cause structural damage. Researchers suggest employing damage avoidance design strategies that rely on energy dissipation devices to reduce harm. Several scholars have looked into the possibility of energy dissipation in buildings. Energy dissipating systems havebeen known to reduce the energy demand on key structural components and minimize potential structural damage by directing the input energy from earthquakes to special devices.

INTRODUCTION

Structure damping, also known as energy dissipation, refers to any element that lessens the movement of structures when subjected to lateral loads like wind and earthquakes. Typical structural engineering techniques aim to increase the structure's capacity in order to meet demand. The opposite strategy, known as passive control, seeks to lessen the load on the building. Energy dissipation or additional dampening is a concept that has undergone substantial development in recent years, and a number of these devices have been put in buildings all over the world. Instead of the more conventional approach of increasing capacity, this strategy aims to decrease the demand on a structure. An overviewof the fundamental ideas, analytical model, and concepts of structural control as they relate to civil engineering structures are given in this work. The structuralcommunity has looked into many strategies for reducing earthquake or wind load induced structure vibrations. The study's focus on vibration management of structures is limited to building applications, even though bridges and other structures can use the same basic techniques.

Low-yield-point steel was used to create steel slit shear walls that dissipated energy at modest lateral drifts, distributed shear deformation evenly among all rows, prevented fracture, and allowed for fat hysteresis without the need for out-of-plane limitations. A small width-to-thickness ratio for the links was made possible by adjusting the dimensions of the link (segment divided by slits) and the number of rows of links while maintaining the necessary shear strength and stiffness.

MOTIVATION AND OBJECTIVE OF THIS STUDY

The main goal is to achieve a higher ductility considering the simplicity and cost- effectiveness of steel slit shear walls. This research evaluates the steel slit shear wall's seismic response to various parameters.

- Finite element analysis of steel slit shear wall
- Parametric study in steel slit shear walls subjected to lateral load by varying number of slits, slit thickness, orientation of slits and height ofslits
- Study the hysteretic behavior of steel slit shear walls

LITERATURE REVIEW

GENERAL

This chapter evaluated previous studies on steel plate shear walls and steel plate shear walls with slits. Since it was used in the lateral load resisting system of astructure, research has been done to comprehend and investigate the applications of steel slit shear walls and steel slit fuses in civil engineering projects. For the purpose of creating a better energy dissipation device for a structure, numerous studies had been carried out. Only a thorough analysis of the parametric change potentials of low yielding point steel slit shear wall systems has been documented in the little literature. The goal of this literature review was to gather as much information as feasible for this topic.

REVIEW OF PAPERS

Toko Hitaka and Chiaki Matsui (2003) developed new type of earthquake- resisting element. A Steel plate shear wall with vertical slits Subjected to static monotonic and cyclic lateral loading. This paper provide data on general behavior of the walls, which provides the basis for models to calculate the wall strength and stiffness and design the out-of-plane stiffening. And also this paper pointing out that when properly detailed and fabricated models was used to in this particular paper the models are sustain roughly

3% drift without substantial hysteretic degradation. **Andrés Jacobsen et.al** (2010) investigated the development of a passive damper device, consisting of a steel plate shear wall with vertical slits. In this paper, the feasibility of the modified slit configuration was demonstrated by finite element analyses. A three-storey building was studied, where steel plate shear walls with modified slit configurations are implemented as shear-resisting elements. The structure was tested using an online hybrid testing technique in this paper this the experiments indicate that the shear walls exhibited stable hysteresis, providing excellent energy dissipation and ductility. **G. Cortés and J. Liu**(2011) conducted a two series of tests. To understand the behavior of the steel slit panels and the steel slit panel–frames. In this paper, the main parameters are to study were the strength, the stiffness, the stress distribution and the failure modes in the first series and the behavior of the steelslit panels within the frame in the second series. The researchers found out that the stiffness in the panels is clearly affected by the flexural rigidity of the beams connected to the panels. And also they found that the stiffness is significantly reduced by other aspects of the supporting frame. The experimental results suggest that the sspw system has high potential, with ductile and predictable behavior. **K. Ke and Y.Y. Chen**(2012) found out that the slitted steel plate walls are good energy dissipators .in this paper, the wall is tested against the lateral load and founded out that the link configurations of the steel slit shear walls are have an important role when it comes to energy dissipation. The researchers also foundout that the plastic buckling in the walls should negatively effect the energy dissipation capacity of the system.as a summation of this paper the aspect ratioas well as thickness to width ratio does influence the plastic energy absorption significantly and the non-linear behavior also imposes an effect on energy dissipation capacity of the wall. **Masahiro Kurata et.al**(2014) adopted a different approach in modelling the slits they adopted a double-tapered shape for the links that will be able to significantly increase the amount of out of plane deformation.in this paper cyclic loading tests for individual links and groups of links are conducted and all specimens with double-tapered links exhibited large ductility, without any fracture **Ugale Ashish B and Raut Harshalata R**(2014) studied the behaviour of the high rise building with and without steel plate shear walls .in this paper they found out thatthe Steel plate increase stiffness of the structure and deflection in the structure also reduced by adding a steel plate shear wall in case of the structure without the steel plate shear wall the deflection buildings where really high .With the use of steel shear walls in the buildings, the bending moments in the column are reduced. Due to relatively small thickness steel shear wall occupy much less space than equivalent reinforced concrete shear wall.

Wang Meng et.al (2015) worked on different type of steel plate shear walls to found out the Energy-dissipating capacity, ductility, out-of-plane deformation and the effect of tension field on the columns. In this paper, the researchers studied various stiffened models and unstiffened as well also different steels with different yield. This paper summaries that the Low yield point steel plate shear wall with T type stiffened ribs exhibits most effectively improve the energy dissipation capacity and ductility, and lesser the impact of tension field on the columns, besides, it had better load-carrying capacity and smallest out- of-plane deformation. **Jin yu lu et.al** (2015) investigated on the stiffened steel plate shear wall with slits find out the force mechanism the models.in this paper, A simplified elastic- plastic analytical model for the stiffened steel slit wall composed of beam elements was presented, where the effects of edge stiffeners were taken into account. As the result of the study the found out that the model provided a lateral stiffness and good strength. Steel slit wall could prevent the beams and columns from being damaged by an earthquake and that the steel slit wall was an efficient energy dissipation component. **Liusheng He et.al**(2016) took an different approach they found out an problem with existing slit shear wall that is fractures formed at the slit ends and pinched hysteresis that reduce energy dissipation. The study comes with the solution that using a low yield point steel that has a low yield stress and large ductility and strain hardening can reduce these kinds of problems .as a result the shear deformation was evenly distributed among all rows fracture was eliminated, and fat hysteresis without the requirement for out-of-plane constraints was feasible. **Jinyu Lu et.al** (2018) investigated on the steel slit shear walls with a unequal length patterns .The steel slitted shear walls obtain higher energy dissipation capacity and better ductility compared with conventional steel plate shear walls.in this paper are a cyclic lateral loading is conducted and both experimental and analytical and those results are similar that a steel slitted shearwall with unequal length is having high energy dissipation capacity and good ductility as well as relatively high lateralstiffness and ultimate bearing capacity when compared with the traditional steel slit shear walls. **Fatemeh Aliakbari and Hashem Shariatmadar**(2019) investigate the overstrength, ductility and response modification factors of moment resistant frame (MRF) with steel vertical slit panel (SSP-MRF) were investigated and determined. Abaqus software was used to perform the static pushover analysis, linear dynamic analysis, and nonlinear incremental dynamic analysis.in this paper they found out that Overstrength factors decrease as the number of stories increases up to a particularlevel of stories and remains unchanged for rest of the structures with a higher number of stories and also Ductility factors decrease as the number of stories increases up to a particular story level stories, and remain unchanged for higher structures.**Ahmad Siar Mahmood Shah** (2020) found the energy dissipation of steel fuselinks. In this paper, a numerical analysis of the cyclic response of steel plate fuses with straight and butterfly-shaped shear links is presented. As input factors, seven design elements relating to the composition or geometry of steel plate fuses are taken into account. In terms of initial stiffness, yield strength, ultimate stiffness, effective damping, maximum strength, and ductility, the cyclic response of fuses is investigated. According to the findings of the sensitivity analysis, the fuse link end- width and thickness have the greatest impact on the overall cyclic behaviour of steel plate fuses, while the fuse link length and mid-width have a limited impact on certain of the cyclic responses. **Haifeng Bu et.al**(2021) investigated to find out contributing factors for the hysteretic behaviour of the steel slit shear walls .there are majorly four models with different categories. First set of the study is to find out the different link configurations and material properties. As a result of the study the paper leads to result of the low yield point steels shear walls with slits show a fat hysteresis and performed well and they reduced the story displacement too. The twisted model also shows improvement Under large earthquake intensity and reducingstory displacement

RESEARCH GAP

Most of the researchers was invested on the steel slit shear wall (SSSW) to findout the energy dissipation capacity under cyclic loading. Especially most of the studies was concentrated on the conventional steel slit shear wall with vertical slits and butterfly link configuration only. Lesser papers are concentrated on the steel slit shear wall with less than 250 MPa of yield strength. There is wide scope for the study of a low yield steel slit shear wall and its parametric studies under lateral loading. The twisted steel slit shear wall (TSSSW) was the one with lesser studies conducted.

STUDY ON FINITE ELEMENT ANALYSIS

GENERAL

The most popular simulation technique for forecasting the physical behaviour of systems is the finite element method (FEM). Due to the fact that utilising computer software to simulate model components is faster and less expensive than employing experimental approaches, FEA is now the standard analysis tool in design.

FINITE ELEMENT SOFTWARE – ANSYS

Engineers use ANSYS, one of the most popular commercial finite element programs in the world, to simulate interactions in all branches of physics, including electromagnetics, fluid dynamics, structural vibration, and fluid dynamics. The simulation of computer models is performed using ANSYS Mechanical FEA software. For this study, ANSYS workbench R2 was used for finite element modelling and analysis. For modelling the behaviour of steel,the element SOLID186 was used.

SOLID 186

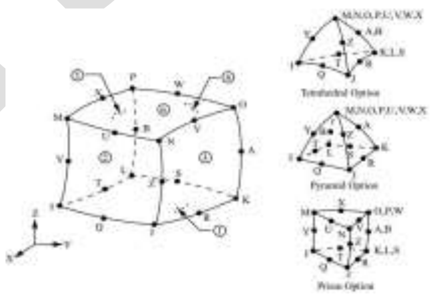

Fig.3.1.SOLID186

Higher-order, 20-node 3-D solid element SOLID186 which displays quadratic displacement behaviour. There are 20 nodes that make up the element, and each node has three degrees of freedom: translations in the nodal x, y, and zdirections. The element is capable of plasticity, hyper elasticity, creep, stress stiffening, huge deflection, and large strain

METHODOLOGY AND VALIDATION

GENERAL

The finite element approach was used in this study for the modelling of steel slit shear walls ANSYS workbench r2. For accurate FE analysis, element type, element mesh, boundary conditions, and material properties of steel plates were considered.

FEM model of steel slit shear wall was then validated.

METHODOLOGY

The models are cyclically loaded and checked for hysteretic behaviour in the validation portion. Based on these studies, it was determined that low yield steel slit shear walls performed better. In the current paper, a thorough finite element model was created using three and a half-sized specimens that were developed to measure the performance of low yield steel slit shear walls in a real frame system. Slit counts, slit thickness, slit inclinations, and slit height are varied in the steel slit shear walls' parametric study, which is evaluated. From the studies conducted, the methodology of the thesis is formulated as below Modelling of steel slit shear wall with ANSYSValidation Pushover analysis steel slit shear wall Investigation on the ductile behaviour of the steel slit shear wall by varying parameter like number of slits, slit thickness, slit orientation and slit height Investigation on the performance of steel slit shear wall under cyclic loading Investigation on the energy dissipation capacity on the basis of hysteresiscurves.

MATERIAL PROPERTIES

Tensile Strength

The basic idea of a tensile test is to place a sample of a material between two fixtures called "grips" which clamp the material. The material has known dimensions, like length and cross-sectional area. We then begin to apply weightto the material gripped at one end while the other end is fixed.

Compressive strength

The compressive strength of mild steel varies depending on the composition andthe degree of cold work or heat treatment, but typically ranges from 75 MPa to300 MPa.

At room temperature and above, mild steel can be expected to fail in a ductile manner. The compression strength will then be equal to the yield stress, which is approximately 250 MPa . At around -60 °C, mild steel undergoes a ductile- to-brittle transition.

VALIDATION OF STEEL SLIT SHEAR WALL

The model of the steel slit shear wall was modelled and validated with the reference paper.” STUDY ON STEEL SLIT SHEAR WALLS WITH DIFFERENT CHARACTERISTICS OF HYSTERETIC BEHAVIOR,”Experimental and numerical study by Haifeng Bu, Liusheng He and Huanjun Jiang .

Geometry and material properties

The ANSYS Workbench R2 programme was used to carry out the finite element modelling. Low yield steel with a 9 mm plate thickness was used to model the steel slit wall. The nominal yield stress of the low yield steel utilised to create steel slit walls was 100 MPa. The low yield steel showed obvious strain hardening without yielding to the plate. The model, which measures 420 mm × 480 mm overall, was depicted in Figure 6.2. The slits are 90mmapart from one another on the middle line. The material properties are shown in Table6.1.

Modelling and Meshing the Geometry

The model was created using a graphical user interface after the relevant material properties had been assigned. The meshing of the steel slit shear wall was shown in Figure 6.2. Mesh creation was the next crucial stage in finite element analysis after model construction. The third-dimensional solid body was meshed with the 20-nodeSOLID 186 structural solid element. The element hexahedron shape was selected formeshing the solid components by combining some of the nodes. The adaptive size control meshing element size of 50mm isused.

APPLICATION OF LOADS AND BOUNDARY CONDITIONS

The steel plate shear wall was sandwiched in between four loading plate two plates atthe top and two plates at bottom respectively. The steel slit shear wall was loaded by a cyclic load in lateral direction at the top loading plate .The bottom plate was fixed supported.as shown in figure 6.3.

RESULTS OF VALIDATION

The outcomes of the ANSYS simulation were contrasted with those of the Haifeng Bu et al's numerical analysis. The FE analysis's deformed forms and hysteretic curvewere consistent with the reference paper's numerical findings. Hysteretic curve and maximum load were used to represent the simulation's results. Deformation, equivalent stress (also known as von-mises stress), and equivalent strain were used todescribe the ANSYS results. The resultant plots of validation are shown below in figure 6.4. Failure observation were anticipated in a manner comparable to that of the cited journal. By clearly demonstrating the strain hardening properties of low yield steel, the hysteretic curve demonstrated the plumpness. figure 6.6, compares the hysteric curves from both the study and the journal. From previous studies, known that out of plane buckling is unlikely to develop in thick plates. This can be another advantage of using low yield steel in SSSWs.

load from the reference paper being 83.10 kN, respectively. The loads were within the acceptable range, Therefore, the model is validated because both thefailure observation and the maximum load of the models fall within the allowable range. Table 6.3 displays the validation findings together with the corresponding drift percent.

SUMMARY

The results of the current study's finite element analysis and the results from thereference publication are displayed in Table 6.3. Both the reference paper and the current study's failure observations are identical to one another. The highestload determined by the current investigation was 90 kN, whereas the highest load determined by the reference publication was 83.10 kN. Both maximum loads are within 5% of one another with regard to displacement drift. The maximum load difference was found to be less than 10%, indicating that the model was validated.

PARAMETRIC STUDY ON STEEL SLIT SHEAR WALL UNDER PUSHOVER ANALYSIS

GENERAL

This chapter includes the parametric study of the steel slit shear wall. For this study, the steel slit shear wall was subjected to push over test. The effects of parameters such as the number of slits in the plate, the slit width, the slit inclinations, and slit height ofthe steel plate was investigated.

GEOMETRIC AND MATERIAL DETAILS OF MODEL

The model's characteristics were covered in Chapter 4; however, the plate thickness and other characteristics remained the same, while a steel slit shear wall was added toa scaled-down frame for the purpose of this study. For each parametric study, the slit configuration and slit thickness were changed. Each section of this article addresses the specifics of these changes. The ANSYS Workbench R2 software was used to create the models.

A frame that is half scaled down and about 2 m wide and 1.5 m tall is employedfor the additional research. This size was chosen since a shear wall's real dimensions of 4m in width and 3 m in height are usual for stories. According to figure 7.1, the boundary elements were constructed using the standard profile I section, and the infillsteel plate thickness was set at 0.9 mm for steel slit shear walls. The dimension detailsof the I section are given Table 7.1.

Meshing

The model was integrated using a graphical user interface after the relevant material properties had been assigned. Figure 7.2. depicts the boundary frame element and the meshing of the steel slit shear wall with 12 number of slits (S12). Mesh creation is the next crucial stage in finite element analysis after model construction. Combining a third-dimensional solid body with the 20-node SOLID 186 structural solid element. The element hexahedron shape was selected for meshing the solid components by combining some of the nodes. For the boundary frame, a meshing element size of 50mm with adaptive size control is employed, and for the plate, a meshing element sizeof 25 mm with adaptive size control. For all models throughout this, the meshing and the material attributes are the same.

Pushover analysis

Pushover analysis is a static method that uses a streamlined nonlinear approach to calculate seismic structural deformations. During earthquakes, buildings are remodelled. As individual ones lose way or fail, the dynamic forces acting on the structure are transmitted to other components. A pushover analysis simulates this phenomenon by applying loads until the structure's weak link is found, and then updating the model to take into account the modifications the weak link has made to the structure. In a later iteration, the loads' redistribution is displayed. The structure is"pushed" once more in order to identify the second weak link. This process is done until a yield pattern for the whole structure under seismic stresses is discovered.

Pushover analysis is commonly used to evaluate the seismic resilience of existing structures in guidelines for retrofit seismic design. It can also help with the performance-based design of new structures that rely on ductility or redundancies to withstand seismic shocks.

Loading and boundary conditions

Displacement-controlled loading was used in the analyses. boundary conditions of themodel S12 were given in Fig.7.3. All other models were provided with similar loading and boundary conditions. The load was given using a

displacement-controlled approach, in which displacement in Lateral direction was allowed but displacement in other direction constraint. All degrees of freedom at the bottom face were constrained, resulting in fixed support at the bottom.

STUDY ON THE INFLUENCE OF NUMBER OF SLITS IN A STEEL SLIT SHEAR WALL

Six models with change in number of slits were investigated to study the effect of number of slit in the steel slit shear walls on the lateral behaviour under pushover analysis. The naming convention used S is used to indicate the slit, and the numeric digit and the thickness of the plate was kept as the same as validation model it was 9mm also the material property was kept same .in this study the slit thickness was keptat 5mm and the spacing of the slit from the top and bottom from the frame is 25mm in all the models. For this analysis, the number of slits varies from minimum of 2 slitsup to maximum of 12 slits and those changes are made in the geometry of the model.For the loading a loadingplate is used. Slit arrangement details are shown in table 7.3.

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