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SEISMIC BEHAVIOUR OF SPRC CUTTING WALLS WITH DIFFERENT STEEL CONTENT AND AXIAL STRESS RATIOS

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Abstract

In this research work, we study the mechanical properties of WTC steels we've collected into five different groups: elasticity, tensile strength at high temperatures, high strain rate at room temperature, impact, and brittleness. During the characterization process, 29 different types of steel were used, each of which matched one of the 12 strength categories of the building. For temperatures up to 900°C, the modulus E and Poisson's ratio v are two examples of elastic properties. We figured out ET) for temperatures below 723 degrees Celsius by looking at data from thermocouples that were put in the steel columns around the WTC's perimeter. Based on what has been written, an estimate has been made of what happens at temperatures above 723 degrees Celsius. At room temperature, samples made from all of the grades of steel used to build the towers showed tensile metrics like yield and tensile strength as well as total elongation. In the paper, models are used to show the stress-strain curves for each type of steel. The observed stress-strain data, the remaining mill test data, and past experience were used to make these curves. Except for a few major outliers, the steels, bolts, and welds that were found met the requirements they were sent to. Sometimes, the measured yield strengths of recovered steels were a little lower than what was allowed. This difference is likely due to a mix of mechanical wear, natural variation, and changes in testing methods. High strain rates can improve things like yield strength and tensile strength, total elongation, and strain rate sensitivity up to 400 s'". There are perimeter and core column steels that can handle high strain rates. All of the parameters that were measured were the same as those that have been reported for other structural steels. Charpy testing was used to look at the impact attributes. The perimeter columns and the core columns were made of structural steel that was similar to other structural steels of the time. When tested at room temperature, almost all WTC steels were found to have impact toughness of more than 15 foot-pounds. At high temperatures, the stress-strain curves of a number of steels that are used for perimeter and core columns and trusses are measured. This paper will show how to figure out the high-temperature stress-strain curves of steels that haven't been characterised yet. The method is based on how the steel acts at room temperature and how other structural steels have acted in the

past, which has been written down. Stress and strain tests done at high temperatures show that WTC steels act like other structural steels of the same age.

Keywords: Seismic Behaviour , steel content , Axial Stress Ratios.

Introduction

The composite shear wall is a new kind of shear wall structure. It is made of both steel plate and concrete. Skyscrapers often use these new shear wall systems to protect against explosions and missiles. Because it can hold a lot of weight and isn't as thick as other walls, the composite shear wall could be used in a number of ways. In super high-rise buildings, where the performance of steel plate and concrete together is more important, this is especially true at the bottom of the core tube, which has been reinforced. But the local instability of the steel plate can cause the steel plates to work poorly together, which can have a big effect on how well composite walls work in axial compression. This is because how well the steel plate works with the composite wall affects how well the composite wall works. In the past few years, some research has been done on how well composite walls hold up against axial compression. Composite walling is made up of two skins of profiled steel sheeting and an infill of concrete. Since there is no connection between the steel plate and the concrete, the walls don't work well together and can't handle as much axial compression. This is because the steel plate and the concrete are not connected properly. Also, he said that when different constructional measures were taken between the steel plate and the concrete to improve how well they worked together, the local buckling of the steel plate and the eccentric cross-section of the concrete changed the axial compressive bearing capacity. During construction, these steps were taken to improve how well the steel plate and concrete work together. that the buckling of steel plates affects the axial compressive bearing capacity of a lightweight steel-foamed concrete-steel composite walling system. They also gave a formula for calculating the axial compressive bearing capacity based on the idea of a steel plate buckling coefficient and an effective width, among other things. Someone suggested using a hook in the shape of a "J" to connect the steel and concrete skins of a shear wall. A mathematical method was made and used on a total of 15 specimens to figure out how much axial compression the steel plate could handle. The algorithm took into account how the steel plate would bend. A steel tube and a high-strength concrete shear wall were used in experiments with axial compression. Because of these tests, a formula was made to figure out how much weight something can hold. Using the results of axial compression tests on the local stability of a composite wall made of two layers of steel plate, a theoretical formula for the elastic buckling of steel plate was made. A model of the core concrete was made using a steel plate concrete composite shear wall with restraint bars.

How the steel plate is arranged in composite walling systems can have a big effect on how well the steel plate and concrete work together, but this hasn't been studied much in the past. Even though the steel plates and concrete work better together if they are put together in a certain way, this is still the case. In the second study, axial compression testing was done on steel plates with

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different shapes. Because of what was found in earlier research, these tests were done. In this study, a way to figure out the axial compressive bearing capacity was found. The calculation takes into account both the local buckling of steel plates and the rise in the axial compressive strength of concrete during confinement. There was a lot of agreement between what was calculated and what was found in the experiment..

Related work

Hao et al. (2017) This paper shows the experimental results and analysis of the axial compression behaviour of a steel plate-concrete composite shear wall with different layout forms of steel plate. This was done to find out how the different layout forms of steel plate affect the axial compression behaviour of a steel plate-concrete composite shear wall. The goal of this study is to find out what happens when steel plates are laid out in different ways. Three different experiments were done. Two of them used composite walls with an embedded steel plate, and the third used a composite wall with an embedded steel plate and two skins of steel plate. All together, the three samples measure 300 millimetres in length, 200 millimetres in width, and 1206 millimetres in height. The results of the tests show that a composite wall made of two layers of steel plate has the best ability for elastic-plastic deformation and the most axial compressive bearing capacity. With the energy method, the critical local buckling stresses of a steel plate were found and compared to the yield stresses. Concrete constitutive models were shown, and estimates of the axial compressive strengths of confined concrete were made based on the different ways that concrete behaves when it is confined. It was suggested that a formula could be used to figure out the axial compression of the composite wall, and the results of the formula and the experiments were found to be in good agreement. When we came up with this method, we took into account the fact that steel plates and reinforced concrete buckle locally at their edges. So, the axial compressive bearing capacity of the composite wall can be affected by the buckling of the steel plate and the concrete inhibiting effect, both of which are affected by the different ways the steel plate is laid out.

Zhi Zhou et al.(2019) In an SPRC building, a shear wall is a wall made of concrete with steel plates embedded in it to resist shear forces. This plan makes use of all the good things about concrete and steel. Both the shear wall's ability to resist moving sideways and its ability to bend have been greatly improved. In this work, we look at the shear wall of the SPRC under cyclic stresses to find out how flexible it is. The goal was to make a nonlinear, three-dimensional finite element model in ABAQUS and compare it to experimental data that had already been published. Then, a parametric study was used to figure out the flexural failure yield and the final rotation of SPRC shear walls. Through an analysis of statistical data, formulas were made to predict the yield and ultimate rotation of an SPRC shear wall.

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Ke Wang, et al.(2021) Because composite shear walls are better than regular reinforced concrete (RC) walls in many ways, scientists have done a number of tests to find out how they react to earthquakes. But the numerical studies can only be used to a certain extent because of how steel and concrete behave and how they interact with each other. This paper shows the results of an ABAQUS-based numerical study of composite shear walls (CWSC) made of steel plates that have been stiffened and concrete that has been poured into them. The mechanics of how the web plate and the concrete work are being looked at right now. With the help of FE models, it is possible to do both parametric analysis and study of how different parameters affect how earthquakes behave. When it comes to hysteresis curves, failure phenomena, ultimate strength, initial stiffness, and ductility, the FE model and the experimental results agree well. Most of the resistance to lateral force comes from web plates and concrete. Research has shown that between 55 and 85% of the wall's sideways force comes from the web plate. The corner of the web plate has the most resistance to vertical force, while the rest of the web plate has the most resistance to shear force. With the help of plates made of reinforced steel, the concrete is divided into several columns, each of which can handle a vertical force on its own. The things that have the most effect on ultimate bearing capacity and elastic stiffness are wall thickness, steel ratio, and shear span ratio. The ratios of shear span to axial compression and axial compression to shear span are the most important ways to measure ductility. The results of the tests and analyses are put into formulas, which are then used to figure out the composite shear wall's ultimate strength capacity and stiffness under cyclic loading. The calculations have a good chance of being able to predict the reported maximum strength.

Wen Wang et al.(2018) Composite steel plate shear walls, or C-SPWs, are a type of shear wall. These walls are made of reinforced concrete and have steel plates inside. If the concrete encasement is thick enough, the infill steel plate might not buckle too soon. Researchers have set nonconservative requirements for the thickness of concrete thanks to approximation elastic buckling analyses. The buckling of a C-SPW can be simulated, but a too simple analytical model is used. Here, a nonlinear finite element method is used to study how C-SPW buckles. To back up this approach even more, a theoretical formula has been made to figure out the buckling strength of C-SPW. Using the results of a nonlinear finite element analysis done on C-SPW, we find the critical drift ratio that corresponds to the infill steel plate buckling by looking at the effects of concrete panel thickness, concrete elastic modulus, infill steel plate thickness, panel aspect ratio, and stud spacing. The finite element analysis is used to figure out how thick the concrete panels need to be so that the C-SPW doesn't buckle before the drift ratio hits the drift

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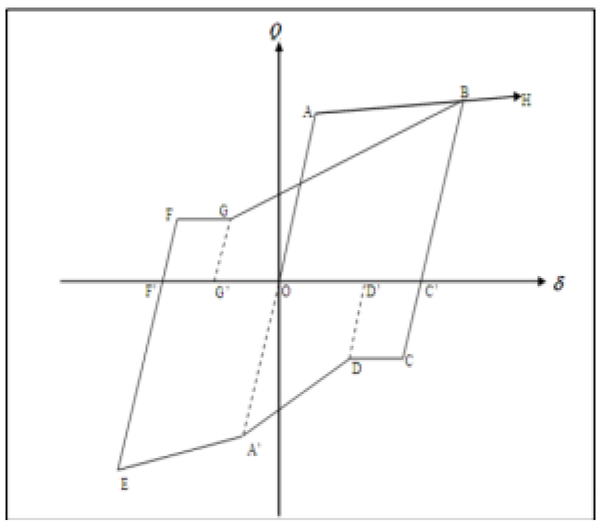
limit (0.4%). To meet the concrete thickness requirement in the design of C-SPW, a formula is proposed that takes into account the minimum concrete thicknesses that are likely to be used.

Methodology

Researchers have been looking into the different kinds of shear walls since the early 1970s. In the next section, we'll look at some of the ways that you can use analysis to predict how shear walls will behave.

analytical ways to study how steel sheet cutting panels change over time. The structural parts of the filler plates are based on the structural parts of the wall panel. Using the standard plate theory, we can predict whether or not the filled plates will be stable.



Hysteresis model [1]

Use the diagonal stress field theory to look at how ultrathin SPSW behaves in shear. The stripes ran in the opposite direction of the voltage range, and the size of each stripe changed based on how thick the strip was. This was called the "multiple stripe pattern." To account for the effect of the lattice and the angle of inclination used in the model of multiple strips, the edge radii were made hard and attached to the columns, and the limit columns were given to the actual stiffness. The amount of strip needed depends on how thick the cutting panels are and how strong the profile pieces are. Findings showed that changes in the angle of tilt didn't have much of an effect on how stable the structure was. sensitivity analyses to find out what factors affect the angle of the tension field.a general modelling technique that independently investigates the structural behaviour of the plate and the steel frame. This modelling technique studies the interaction of both elements and, therefore, is known as the frame plate interaction model.

This method is called "MPFI," which stands for "modified plate frame interaction modelling." It was used by SPSW so that the different heights of the system could be taken into account. We looked at and analysed the MPFI strategy using the ABAQUS programme and the Finite Element Method. The results show that the MPFI method and the FEM pretty much agree with each other.

Shear Strength Model

A link to the Design Model for Composite Structures is given for the shear strength equation.

$$V = V_c + V_s + V_a + V_p$$

Shear strength, V, is made up of four parts: the shear resistance of the concrete (Vc), the shear resistance of the horizontal reinforcement (Vs), the shear resistance of the boundary steel profiles (Va), and the shear resistance of the steel plate that is embedded in the concrete (Ve) (Vp). In Equation 5, the formulas for the different parts of shear strength are given.

$$\begin{cases} V_c = 0.67 f_t b_w h_0 + 0.2N \frac{A_w}{A} \\ V_s = f_{yh} \frac{A_{sh}}{s} h \\ V_a = \frac{0.3}{\lambda} f_a A_a \\ V_p = \frac{0.6}{\lambda - 0.5} f_p A_p \end{cases}$$

where ft is the tensile strength of the concrete, bw is the width of the web, and hw is its depth. The depth (h) and effective depth (h0) of the shear wall section are written as and. An axial compressive load N is less than 0.2 fcbwhw, where Aw and A are the areas of the concrete web and the whole section, fyh is the yield strength of the transverse web reinforcement, fa is the yield strength of the boundary I-shaped steel profiles, and fp is the yield strength of the embedded steel plate. Ayh, Aa, and Ap are the areas that correspond to the three separate parts. s is the distance between the transverse reinforcements, and an is the aspect ratio.

Conclusion

[1]. This article talks about a composite shear wall system made of high-strength reinforced concrete and steel plates. This system can be used in high-rise building construction to resist lateral loads. Eleven RCSW and RCSPSW specimens were tested with quasi-static cyclic lateral loading to find out more about the things that affect how well buildings handle earthquakes. Some of the things that were thought about were steel plate embedding, aspect ratio, axial compression ratio,

and other similar things. As the test went on, important metrics like the lateral load capacity, the maximum displacement, the ductility factor, and the EVD coefficient were calculated and kept track of, as were the damage and failure mechanisms. Using the design models given, you can figure out the shear and flexure strengths of RCSPSW. After putting the data from the experiments through a statistical analysis, one might come to the following conclusions.

[2]. As the aspect ratio goes from 1.5 to 2.7, the most common modes of failure are shear and flexure, in that order. On the shear specimens, there were angled cracks, but most of the flexure-tension and flexure-shear cracks were in the lower half of boundary elements and wall webs. In the RCSPSW samples, the cracks were smaller and more evenly spread throughout the material, while in the RCSW samples, the cracks were bigger and farther apart. As axial compressive loads go up, the number and width of cracks go down because compression forces cause the material to get smaller.

[3]. The RCSW samples' hysteresis loops showed pinch effects. Because the steel plate is embedded, the hysteresis curves are smoother and the peak lateral load capacities are higher. But this isn't as important as the fact that strength and stiffness drop much more after the peak.

[4]. The RCSPSW system has much higher lateral load capacities compared to RCSW in general. With an ultimate drift value of 1.0%, the RCSPSW shear specimens are flexible enough to be used in design.

[5]. It has been found that the axial compression ratio has a big effect on how wall specimens respond to side loads .As the axial compression ratio goes up, the peak lateral load and the final displacement tend to go up, but the peak lateral load and the final displacement tend to go down. When the axial compression ratio was more than 0.50, the strength and stiffness of RCSPSW flexure specimens went down more quickly. When the axial compression ratio goes up to 0.58, the ductility factor goes down to 2.61 and the drift goes down to less than 1%.

[6]. The fact that high-strength concrete is brittle helps to explain why the RCSPSW specimens were much less likely to bend under high axial compression ratios. Due to the low wall thickness values of the test specimens, the weak concrete confinement effect may have had a bad effect on the steel plate that was implanted. When severe concrete spalling happens under higher axial compressive loads, the steel plate buckles, which makes it much less strong and stiff.

[7]. Shear mode of failure usually wastes more energy than flexure-controlled failure, and the embedment of steel plate greatly improves the RCSW's ability to waste energy effectively.

[8]. When it comes to the shear and flexure strengths of RCSPSW, the suggested design models tend to give conservative design values [8]. If you use the

correction factors ks = 0.9 and kf = 1.1, you can get a respectable amount of conservatism.

When there are high axial compressive stresses, shear walls should be built carefully [9], and an upper limit of axial compression ratio of 0.5 should be set for RCSPSW based on test results. Detailing a high-strength RCSPSW system requires using steel ties or shear studs to strengthen the bond between the steel plate and the concrete on both sides. Also, for the best concrete confinement effect, a higher transverse reinforcement ratio is suggested.

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