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Effect of Corrosion on Pushover Performance of a Steel Plate Shear Wall

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***Abstract*— In some areas with the probability of chemical attacks such as near the sea or oil refinery, steel plate shear walls (SPSWs) may be affected by corrosion and after a while gets loss of efficiency. In present study, the effect of web plate corrosion on pushover behavior of a single SPSW is investigated. For this purpose, experimental tests were conducted on SPSW specimen whose web plate corroded according to ASTM B117 and also on uncorroded specimen for comparison. The specimens were subjected to pushover loading and performances of the SPSWs were evaluated. The results show that the corrosion has a significant effect on the behavior of the SPSWs such as initial stiffness and shear capacity.**

***Keywords*— Corrosion, steel plate, shear wall, pushover**

I. Introduction

National Association of Corrosion Engineers (NACE) announced the direct corrosion cost about 3.1% national gross products of US (around 276 billion US dollars) [1]. Whereas corrosion and fatigue are main difficulties in steel structures, it should be noted that rehabilitation of steel structures which were exposed to high level of corrosion are more economical in comparison to rebuild them.

Application of steel plate shear walls (SPSWs) has been spread to resist against lateral load such as wind and earthquake in building structures. SPSW contains a web plate connected to the boundary beams and columns. The web plate of SPSW provides primary lateral strength of the system and also a relatively vast area to dissipate the energy by plasticity [2,3].

For structures built near the sea, oil refinery and so on, corrosion attack can be a serious problem. Web plates of SPSWs, particularly, may be affected by corrosion attack due to environmental destructive effect because of the relative small thickness and the vast steel surface.

In present study, the effects of web plate corrosion on the behavior of SPSW, such as initial stiffness and maximum resistance are investigated. For this purpose, some experimental tests were conducted on corroded and uncorroded SPSW specimens and their behavior under pushover loading were evaluated.

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II. Experimental Programs

A. *Test Setup*

The test specimen, the test set up and the specimen dimensions is schematically shown in fig. 1 and fig. 2. In this work, for evaluation the relative corrosion the ASTM B117 [4] Salt Spray (Fog) test as accelerated tests is applied. In this test, the specimen is situated in an enclosed salt spray cabinet and subjected to an indirect spray of a neutral (pH 6.5-7.5) salt water solution.

The ASTM B 117 [4] test salt fog is composed of 5% NaCl and 95% distilled water. Salt fog should be consisting of pure solution of NaCl and distilled water and without any impurity and solid particles.

Panel members must easily to be exposure to the steam and saltwater and the experimental test must be accomplished in a closed place, the pH level of the solution and temperature of closed place must be set up according to the standard specified test methods. Experimental test carry out and the loss of weight is measured.

Figure 1. A typical specimen of single SPSW.

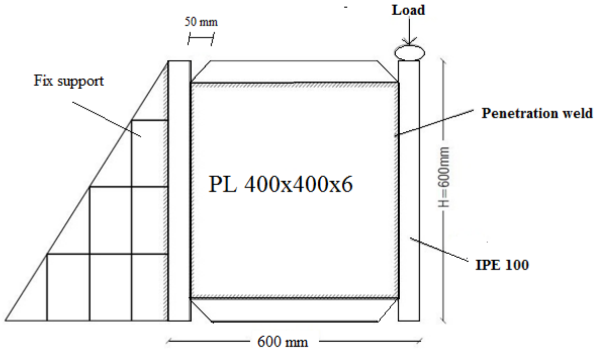

Figure 2. Schematic of the test setup.

B. Material properties

Material properties of steel plate and boundary elements which are used in the specimens are shown in table 1.

TABLE I. MATERIAL PROPERTIES OF STEEL PLATE AND BOUNDARY MEMBERS

Material	Elastic modulus (kg/cm^2)	Yield strength (kg/cm^2)	Ultimate strength (kg/cm^2)
PL 400×400×6	2.1×10^6	2400	3200
IPE 100	2.1×10^6	2400	3200

III. Experimental Results

The test SPSW specimens including of a specimen without corrosion and a corroded specimen under 1 day corrosion condition were subjected experimentally to pushover loading.

Load and displacement of the load application point were measured and plotted in fig. 3. As seen, the corrosion has a very significant effect on the initial stiffness of SPSW specimen; so that the specimen under corrosion loses about 60% of its initial stiffness. Also, as obtained from the experimental curve, the effect of corrosion on the shear capacity also is significant; so that

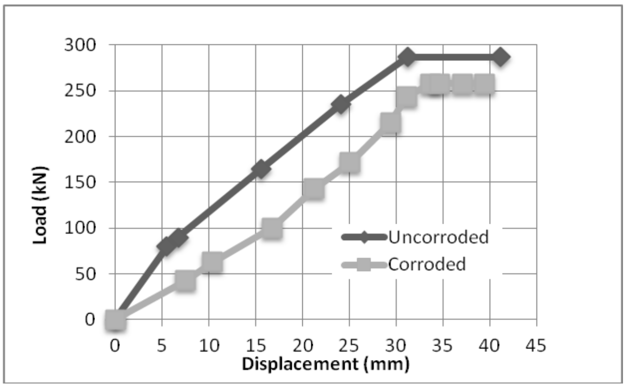

Figure 3. Load-displacement curves of the SPSW specimen.

the specimen under corrosion loses about 10% of their capacity.

For the purpose of comparing, the theoretical shear capacities of the specimens are also obtained as below [5].

$$V_n=0.42\, F_y\, t_w\, L_{cf}\, \sin 2\alpha\,. \quad (1)$$

where, Fy is yield strength of the plate, t_w is thickness of the web plate, L_{cf} is the clear length of the web panel between column flanges and α is the tension field angle. Calculating for the uncorroded specimen, it would be obtained ($\sin 2\alpha = 0.98$) and (V_n = 237 kN).

In order to calculate the shear capacities of the corroded specimens by using equation (1), it is needed to have the specimen's thicknesses reduced by the effect of corrosion. They are simply obtainable by measuring the weights of specimens before and after corrosion. Table 2 shows the weight loss and also the thickness reduction of all specimens.

TABLE II. WEIGHT LOSS AND THICKNESS REDUCTION OF SPECIMEN DUE TO EFFECT OF CORROSION

Corrosion rate (day)	Weight (Before corrosion) (g)	Weight loss (g)	Thickness reduction (%)
0	7460	0	0
1	7425	50	0.67

Using table 2 and equation (1), the theoretical shear capacities could be calculated. As seen, reduction of the plate thickness due to the effect of corrosion has negligible effect on calculated shear capacity, while the experimental results for shear capacity show a significant decreasing due to the effect of corrosion. Hence, it seems that what causes the significant effect on the shear capacity is the change in material properties at the outside surfaces of plate due to the effect of corrosion rather than decreasing of the thicknesses.

IV. Conclusions

In this research, two single SPSW specimens are subjected to pushover loading test, in which one of them is without corrosion and the other with corrosion. The observations of the experimental tests are as following:

1- Corrosion has a very significant effect on the initial stiffness of SPSW specimen; so that the specimen under corrosion loses about 60% of their initial stiffness.

2- Corrosion has a significant effect on the shear capacity of SPSW specimen; so that the specimen under corrosion loses about 10% of its capacity.

3- Reduction of plate thickness due to the effect of corrosion has negligible effect on calculated shear capacity. It seems that what causes the significant effect on the shear capacity is the change in material properties at the outside surfaces of plate due to the effect of corrosion rather than decreasing of the thicknesses.

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