20326287
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Influence of initial deflection shape on the buckling load capacity of steel plate

1. Purpose of the research

Buckling resistance capacity analysis is performed using the first mode of buckling obtained from linear buckling as initial deflection and is compared with the case of using a sine wave shape. This modeling considers the reduction in plate thickness due corrosion and stiffener height due to residual stress.

2. Explanation of model analysis

The target of this analysis is a flat plate with a stiffener attached in the center of the web.

Specifications:

- Web's height H=1000mm, width B=1000mm, thickness t= 9mm, Steel grade SM490Y (σ_y=355 N/mm^2)
- Stiffener's height H=100mm, Steel grade SM400 (σ_y = 235N/mm^2), thickness t=9 mm

In these specifications, the stiffness of the stiffener satisfies the equation below.

$$I = \frac{100^3 * 9}{3} = 3\times10^6 mm^4 > \frac{bt^3}{11} * \gamma_{req} = \frac{1000 * 9^3}{11} * 30\frac{1000}{1000} = 1.99\times10^6 mm^4$$

Boundary conditions

- a-b line: $u_z = \theta_y = 0$
- c-d line: $u_z = \theta_y = 0$
- a-c line: $u_x = U$, $u_z = \theta_x = 0$
- b-d line: $u_x = -U$, $u_z = \theta_x = 0$
- On the intersection of stiffener and plate: $u_z = 0$

Here, U is the forced displacement.

Gradually increase the forced displacement U, the compression buckling strength is calculated by elasto-plastic nonlinear analysis.

When doing an elasto-plastic nonlinear analysis, for the initial deflection of flat plate, is used the following 2 types for compare the strength.

- S1: Using the 1st buckling mode by linear buckling analysis that occurs when applying the forced displacement as the initial deflection form.
- S2: Using the form that describes the following trigonometric function as initial deflection form.

$$w = sin\frac{2\pi x}{B} sin\frac{\pi y}{H}$$

However, H/500 is used for the size.

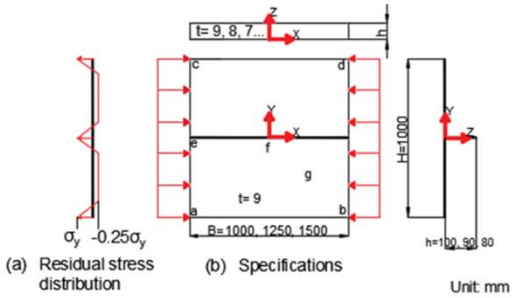
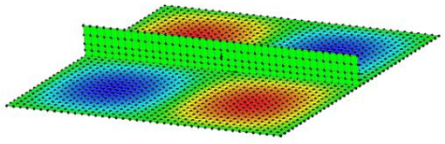


Fig-2 Stiffening plate with compressive force

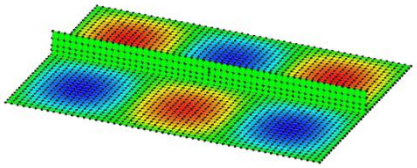
Compare the load capacity in case the stiffener height and web thickness decreases by corrosion. Also increase the horizontal length and compare load capacity in a plate with higher slenderness.

3. Form differences between the two shapes of initial deflection.

- **Initial deflection shape S1: 1st mode of linear buckling**



B=1000mmn H=1000mm



B=1250mmn H=1000mm

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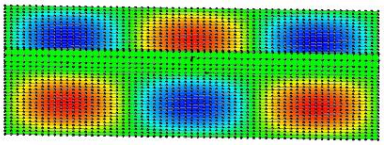
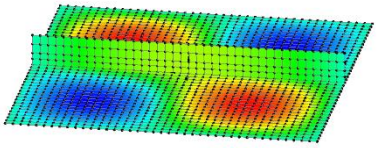


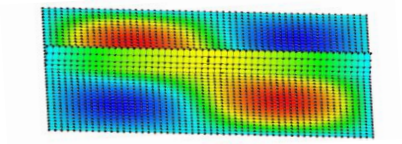
B=1500mmn H=1000mm

The contour plots above show where the displacements in the z axis are when the plate takes the initial deflection of the shape S1. As can be seen, when the first linear buckling mode of the plate is used, the deflections are generated in blocks on the side of the stiffening rib that increase as the horizontal length of the plate increases and the stiffener does not suffer any displacement.

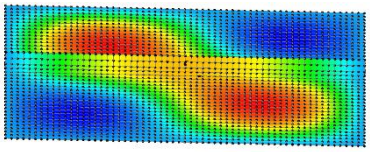
- **Initial deflection shape S2: wave that describes the trigonometric function**



B=1000mmn H=1000mm



B=1250mmn H=1000mm



B=1500mmn H=1000mm

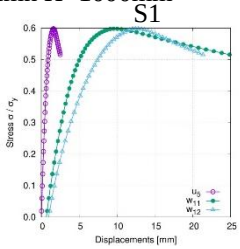
In these contour plots it is seen how the displacements are distributed in z when the initial deflection is of type S2. When the plate acquires the shape of the wave described by the trigonometric function, there are positive displacements distributed diagonally in the plate that begin to be negative when advancing to the corners and they also affect the stiffener, these do not change in shape as the horizontal length increases, but rather they expand.

4. Analysis results

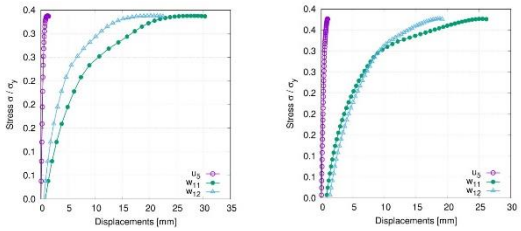
When B=1000mmn H=1000mm

S1 S2

t=9mm h=100mm

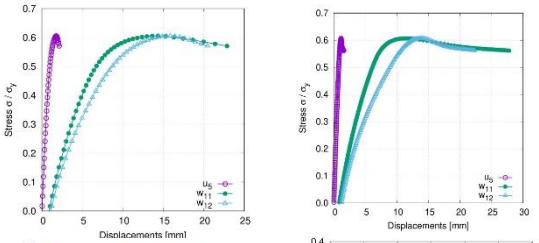


t=9mm h=50mm

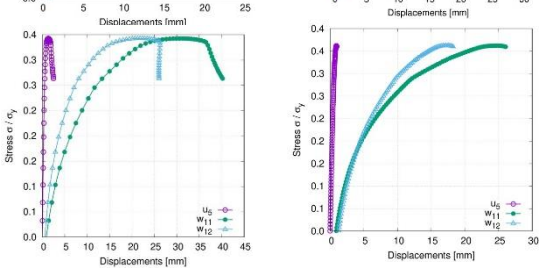


B=1500mmn H=1000mm

t=9mm h=100mm



t=9mm h=50mm



5. Conclusions

Reducing the dimensions of the height of the stiffener and the thickness of the web of the plate, it is clearly seen that with shape S1, the buckling resistance capacity is greatly reduced in relation to the load capacity that it has with shape initial deflection S2. On the other hand, with the plates with the horizontal length greater than the vertical, a sudden decrease in load capacity is observed after reaching the maximum stress, this with the initial deflection of the first linear buckling mode. Therefore, it can be concluded that this type of deflection has a greater influence on the reduction in buckling resistance.