

# COMPARISON BETWEEN EUROCODE APPROACH AND GEOMETRICAL NON-LINEAR ANALYSIS ON SECOND ORDER EFFECTS

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## INTRODUCTION

Comparing results from a Geometrical Non-Linear Analysis (GNIA) and Eurocode approach allows engineers to understand when Eurocode approach is:

- Unsafe
- Too conservative
- Accurate to use

## SECOND ORDER EFFECTS

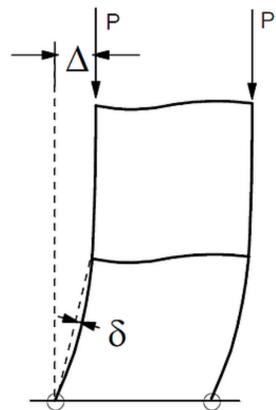


Figure 1. Second Order Effects

The two second order effects are:

- P-δ Local Effects
- P-Δ Global Effects

P-δ local effects are caused by local bow imperfections of the member.

P-Δ global effects are caused by the change of nodal displacement due to P-δ effects.

## Eurocode Approach

The two approaches provided by the Eurocode are:

- The sway-mode buckling length method
- The amplified sway-moment method

The second order effects are taken into account by using the sway effective length to reduce the design capacity of the members. While the amplified sway-moment method amplified the horizontal loadings of the design loads and uses the non-sway effective length to reduce the design capacity of the members.

## ACKNOWLEDGEMENTS

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## REFERENCES

British Standards Institution (2005) *Eurocode 3: Design of steel structures Part 1-1 General rules and rules for buildings, BS EN 1993-1-1*, BSI, London

## FRAMES TO CONSIDER

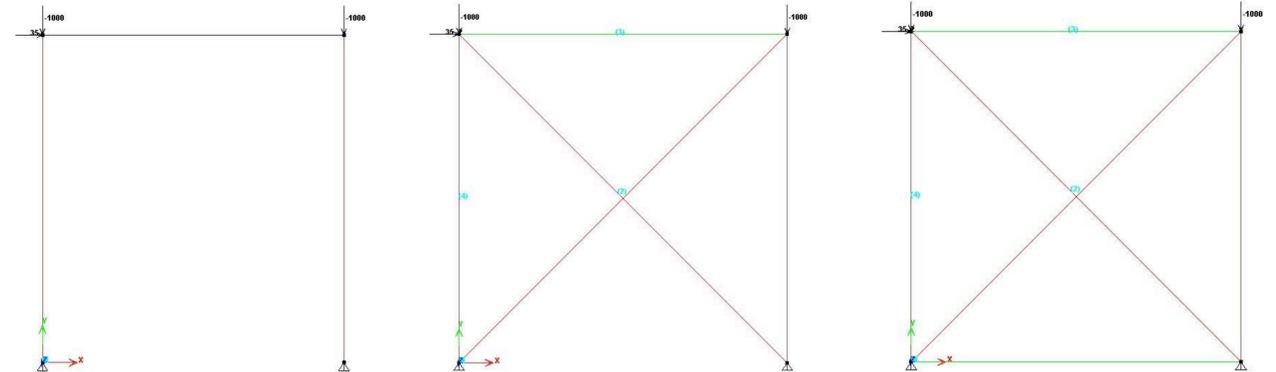


Figure 2. (a) Sway sensitive frame

(b) Non-sway frames

(c) 2<sup>nd</sup> Storey Non-sway frames

## COMPARISON

Each frames are analysed using:

- GNIA with actual imperfections
- GNIA with imperfections provided in Eurocode
- GNIA with global imperfections only
- Linear analysis with sway effective length
- Linear analysis with amplified sway-moment

GNIA with actual imperfections is used as bench mark frames and the failure load factor was found according to Clause 6.2.1(7):

$$\frac{N_{Ed}}{N_{Rd}} + \frac{M_{y,Ed}}{M_{y,Rd}} \leq 1$$

## CONCLUSION

Sway-mode buckling length method will always produce conservative design which is uneconomical to build.

Amplified sway-moment method is accurate when P-δ is the critical second order moments but too conservative when P-Δ is the critical second order moments.

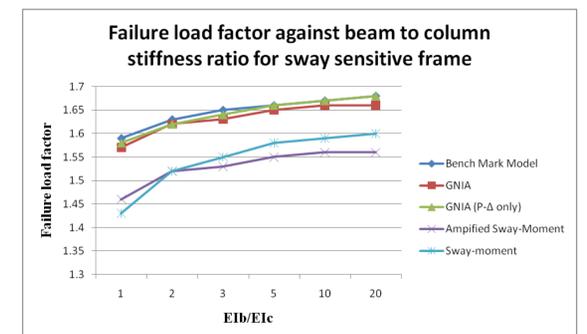


Figure 3. Results for sway models

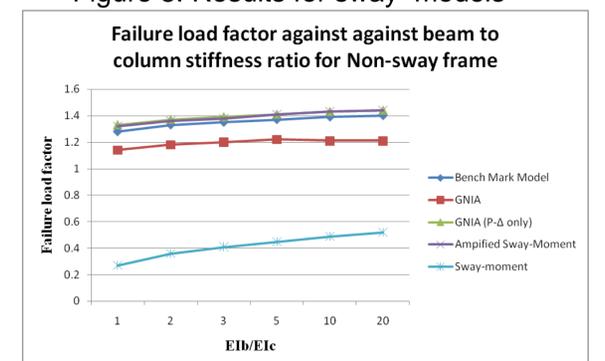


Figure 4. Results for non-sway models

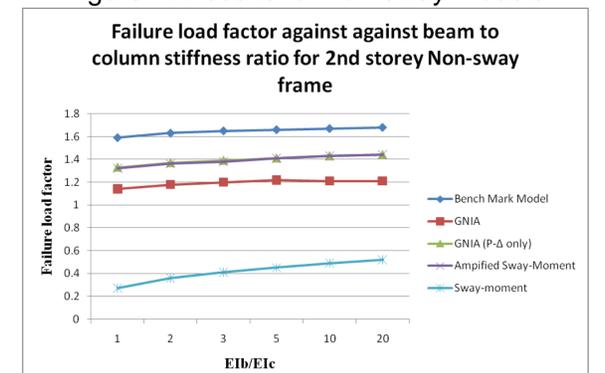


Figure 5. Results for 2<sup>nd</sup> storey non-sway models