Osdag®

Open steel design and graphics

Semester Long Internship - 2021

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Introduction to Osdag

- Osdag is a cross-platform free open source software for the design and detailing of steel structures.
- It follows the guidelines,clauses based on Indian Standard(IS) 808:2007 code book.
- It allows the user to design steel connections,members which is typically optimised by following the industry best practices using a graphical user interface(GUI).
- GUI provides a 3D visualisation of the designed component,allows the user to create 2D drawings which can be imported into autocad.
- It also allows the user to create a detailed professional design report with standard views of the designed component.
- Osdag is primarily built upon Python and Python based floss tools such as PyQt , PythonOCC , OpenCascade etc.

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Description of the task(s) allotted

Selection for the Semester Long Internship was based on Screening task which was additive to the actual problem statements.

The list of tasks which were alloted to me are mentioned below:

1. Preparation of DDCL
   - Development of DDCL for Compression members.
   - Solving examples from standard resources.
2. Testing of developed module
   - To test the developed module with various cases and reporting bugs/Issues.
   - Development of Excel sheet for manual verification with developed module.
3. Development of technical reports and layout of GUI
   - Preparation of draft for technical report containing all the detailed design calculations and steps of solved problems.
   - Preparation of GUI layout for input and output dock's.

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Problem solving method(s) adopted

1. Methods adopted to solve the tasks:

    - Studied different procedures followed by various standard textbook's and developed DDCL covering almost all the possible cases.
    - Used Excel for testing of module with examples, incase of any mismatch in values the bug/Issue can be identified easily.
    - Went through the written alogorithm for compression module to understand the nuances of developed code.
    - Learned and used latex for document's preparation.

2 References followed:

- Ghosh S et al. (2021) Osdag: A Software for Structural Steel Design Using IS 800:700. In: Adhikari S., Dutta A., Choudhury S. (eds) Advances in Structural Technologies. Lecture Notes in Civil Engineering, vol 81. Springer, Singapore
- IS 800:2007, General Construction in Steel-Code of Practice, Third Revision, Bureau of Indian Standards (BIS), New Delhi
- Design of Steel Structures (2013), N. Subramanian, 12th Impression, Oxford University Press
- Design of Steel Structures, S. Ramamrutham, Dhanpat Rai Publishing Company

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Introduction to Column Design

- Axial loading on columns is due to loads from floors, walls and roofs which are transmitted to the column through beams and also because of its self weight.
- The response of a column to an axially applied load depends on length of the member, material characteristics, its cross section geometry, support conditions, residual stresses and imperfections.
- There can be different modes of possible failures in axially loaded compression members like squashing, overall flexural buckling, torsional buckling, local buckling and local failure.

Failure modes in compression member

- Squashing occurs in columns having relatively smaller length. It occurs by yielding of cross-section of the column.
- The cross-sections are deflected without any torsional rotation in the case of Overall flexural buckling. If no lateral restraints are provided across the member length, the weaker axis of the cross-section starts deflecting.
- Torsional buckling is a less common type of failure, and looks like the member is subjected to torsional moments. In this type of failure the cross-sections are rotated around the longitudinal member axis without accounting to any deflection.
- A combination of both flexure and twisting failure is possibly known as Flexural- Torsional buckling and occurs in open cross-section having single symmetry or no symmetry at all.
- Local buckling is a major concern in the design of steel structures, it occurs in hot rolled steel sections usually having outstanding flange elements with unsupported edges and which are thin and slender. Local buckling greatly reduces the axial load carrying capacity of column sections.

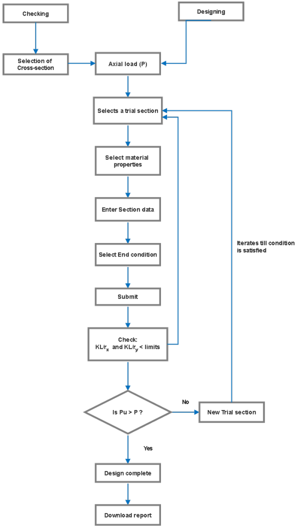

Figure: Flowchart of design process in Osdag

My contribution towards the project

1. Preparation of DDCL for Compression members with solved examples
   - Went through several standard textbooks and understood the detailed working procedure of different cases possible.
   - Developed DDCL for Axial load, Axial load and Bending moment on columns comprising of all the possible cases by giving proper validations.
   - Solved various different examples to make sure the developed procedure is working fine.
   - There are two possible cases for axial load on columns i.e. to find load carrying capacity of section and design of columns for axial load. The procedure is given in next slides.

The design procedure is as follows

- A section is to be selected for which load carrying capacity is to be found out or With the given axial load (P) the required area should be found out in the case of design.
- Based on the selected section, the sectional properties will be auto imported from the database.
- For the selected section buckling class will be defined as per Table 10 of IS 800:2007.
- The selected section is classified into plastic, compact and semi-compact according to Table 2 of IS 800:2007.
- If all conditions are satisfied as given in Table 2, then the effective area (Aeff) is taken as gross area as long as the section is semi-compact or better. Otherwise reduction should be made considering the holes not fitted with rivets or bolts from gross area to calculate effective sectional area respectively.

- Slenderness ratio (λ) should be calculated and check for the limits from Table 3 of IS 800:2007.

$$\lambda = \frac{KL}{r_{min}}$$

Where λ is the slenderness ratio, KL = effective length from Table 11 of IS 800:2007 and r_{min} is the minimum radius of gyration.

- Calculate the design compressive stress (fcd) as per clause 7.1.2.1 of IS 800:2007, which is given by,

$$f_{cd} = \frac{f_y/\gamma_{mo}}{\phi + [\phi^2 - \lambda^2]^{0.5}} \leq f_y/\gamma_{mo}$$

γ_{mo} = partial safety factor as per table 5 of IS 800:2007 = 1.10
ϕ = 0.5[1+α(λ-0.2)+λ^2]
λ = Non dimensional effective slenderness ratio = $\sqrt{f_y/f_{cc}}$
f_{cc} = Euler buckling stress = $\frac{\pi^2 E}{(KL/r_{min})^2}$
KL/r = effective slenderness ratio of eff. length
α = imperfection factor given in Fig.1 (table 7 of IS 800:2007)

- Calculate the design compressive strength (Pd) as per clause 7.1.2 of IS 800:2007 which is given by,

$$P_d = A_{eff} * f_{cd}$$

If P_d is greater than P, Design is safe otherwise repeat from step 2 by selecting a section having more area than previously selected section.

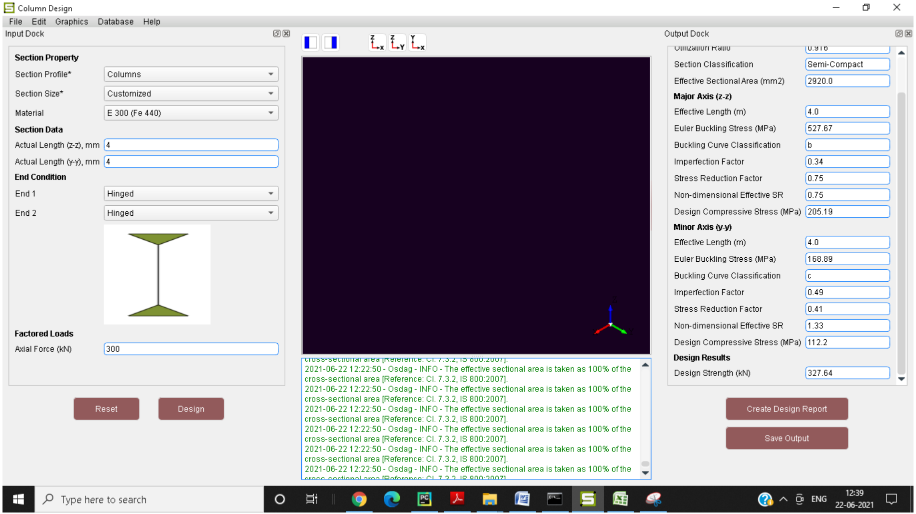

Figure: Solved example in Osdag

My contribution towards the project

2 Testing of Compression member module

- Testing was a major phase of the project. Exact design procedure was prepared in MS Excel by giving proper validations.
- Excel sheet was prepared in such a way that only by giving the input values and in a click all the output results will be displayed.
- Major functions like Vlookup,Hlookup,data validation were used to get the desired output.
- Figures of the prepared Excel sheet can be viewed in next slides

Solving for which type of section	Hollow	

Input Data:		
Section:	CHS 114.3 x 3.6	
Material:	E 250 (Fe 410 W)A	
Factored load:	300	kN
Column length along z-z	3	m
Along y-y	3	m
End condition:		
At one end : Translation	Restrained	
Rotation	Restrained	
At other end : Translation	Restrained	
Rotation	Restrained	
Effective length along z-z	1950	mm
Along y-y	1950	mm
Yield stress:	250	Mpa
Assumed fcd	125	Mpa

Figure: Input details

Area Required	2400	mm^2

Buckling Class about z-z :	a
Buckling Class about y-y :	a

Section classification		
For Hollow	-2.00	#N/A
For Hollow	31.75	Semi-Compact

Major Axis z-z	
Effective length (m)	1.95
Euler Buckling Stress (Mpa)	797.69
Buckling Curve Classification	a
Imperfection Factor	0.21
phi	0.69
Stress Reduction Factor	0.90
Non-dimensional Effective SR	0.56
Design Compressive Stress(Mpa)	205.59
Design Compressive Strength(kN)	257.40

Figure: Output details

Minor Axis y-y	
Effective length (m)	1.95
Euler Buckling Stress (Mpa)	797.69
Buckling Curve Classification	a
Imperfection Factor	0.21
phi	0.69
Stress Reduction Factor	0.90
Non-dimensional Effective SR	0.56
Design Compressive Stress(Mpa)	205.59
Design Compressive Strength(kN)	257.40
UR	1.166

Figure: Output details

My contribution towards the project

3 Development of report and layout of GUI

- A draft was prepared for report comprising of all the detailed design steps used in the calculation.
- Layout of GUI was designed with the help of Input and Output parameters, which needed to be displayed.
- Below is given the figure of technical report draft.

Design Report draft for Axial load only

Module	Compression Member Design – Axial load on column
Axial (kN)*	
Length(mm)*	
End Conditions*	
Section Profile*	
Section Size*	
Section Material	
Ultimate Strength, F_u (MPa)	
Yield Strength, F_y (MPa)	

1.1 List of Input sections

Section Size*	

Figure: Input details

2 Design Checks

2.1 Selected Member Data

Image of I section	Section Size*			
	Material			
	Mass, m (kg/m)			
	Area, A (cm^2)			
	D (mm)		r_z (cm)	
	B (mm)		r_y (cm)	
	t (mm)		Z_z (cm^3)	
	T (mm)		Z_y (cm^3)	
	R_1 (mm)		Z_{pz} (cm^3)	
	R_2 (mm)		Z_{py} (cm^3)	
	I_z (cm^4)			
	I_y (cm^4)			

2.2 Buckling Class

Check	Required	Provided	Remarks
h / b_f			
t_f			

2.3 Cross-section classification

Check	Required	Provided	Remarks
b / t_f	<= 15.7ε b = b_f / 2		

Figure: Output details

	$\acute{\varepsilon} = (250 / F_y)$^0.5		
d / t_w	<= 42$\acute{\varepsilon}$ $d = h - 2 (T + R_1)$ $\acute{\varepsilon} = (250 / F_y)$^0.5		

2.4 Member Check

Check	Required	Provided	Remarks
Slenderness	KL / r_{min} <= 180	KL / r_{min}	Pass or Fail
Design Compressive stress (f_{cd})	f_{cd} <= F_y / gamma mo	Φ = α = λ = f_{cd}	Pass or Fail
Design Compressive strength (P_d)	Axial (kN)	$P_d = A_{eff} * f_{cd}$	Pass or Fail

Figure: Output details

How has my contribution improved the project

- New module on compression member will be added soon as the other cases get's completed. Basic design case has been fully developed and completed.
- Some bugs which were identified while checking for crashes made a huge difference for the whole module.
- The EXCEL sheets prepared can be used anytime in future .
- The sheets were prepared in such a way that desired output can be found in just one click.

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My key takeaway(s) from this Internship

- Although the Internship was offered in remote mode that didn't stop the learning process.The Intersnhip was conducted in a very smooth way with the help of available communication tools.
- It helped me to learn many things from the Internship like team work, time management ,importance of programming in Civil engineering , increased my knowledge in structural steel design and made me realise were I stand in terms of subject knowledge.
- The Internship made me to choose a proper career goal and i definitely believe that it would help me in my life as I move further.
- I feel grateful to get a oppourtunity to work with FOSSEE and to meet professionals who guided , helped me taking their time.

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Thank You