EN2208: Computing in AEC – coursework 1 (60%)

Dr. Haijiang LI, November, 2012.

The question description:

You are required to make a C++ program to conduct timber component (beam and column) structural design according to EC5 (all the relevant design codes have been uploaded onto the Blackboard). It is limit state design, various sets of ***factors*** are applied to both actions and material strengths with different factors being used for different conditions. You need to compare design actions with the design strengths.

Design actions: $F_d = \gamma_F F_k$

Permanent actions ($G_d = \gamma_G G_K$) include all dead loads acting on the structure, $\gamma_G = 1.35$;

Variable actions ($Q_d = \gamma_Q Q_K$) include the imposed, wind and snow loads, $\gamma_Q = 1.5$

k: characteristic value; d: design value; γ : partial factor; F: Action

For example:

To calculate the design action, information is given below:

- Self-weight: 0.12 KN/m^2
- Permanent action of boarding: 0.03 KN/m^2
- Variable action: 1.8 KN/m^2

Design action: $F_d = \gamma_F F_k = r_G G_k + r_Q Q_k$

= 1.35 x (0.12+0.03) + 1.5 x 1.8 = 2.9 KN/m^2

Design Strength: $R_d = X_k / \gamma_m$

R: resistance; X: Material property; d: design value; k: characteristic value; γ: partial factor

For timber: $$f_d = \frac{k_h \, k_{sys} \, k_{\mathrm{mod}} \, f_k}{\gamma_m}$$

- γ_m is a partial coefficient (safety factor) for material properties
- k_{mod} is a modification factor which accounts for the duration of loading and climatic conditions
- k_h (member size factor, bending and tension) and k_{sys} (load sharing factor) are equal to 1.0 except some special circumstances

$$k_h = \min\left\{\left(\frac{150}{h}\right)^{0.2}, \ 1.3\right\}$$

For example:

To calculate the design strength, information is given below:

- Characteristic values for C16 Timber:

Bending strength: $f_{m,k} = 16.0 N/mm2$

- γ_m : for solid timber-untreated and preservative treated: 1.3
- k_h : assume depth is less than 150 mm, say: 1.3
- k_{sys} : there is load sharing system: 1.1
- Solid timber: Service Class 2
  - Permanent actions: k_{mod} = 0.6
  - Medium-term actions: k_{mod} = 0.8

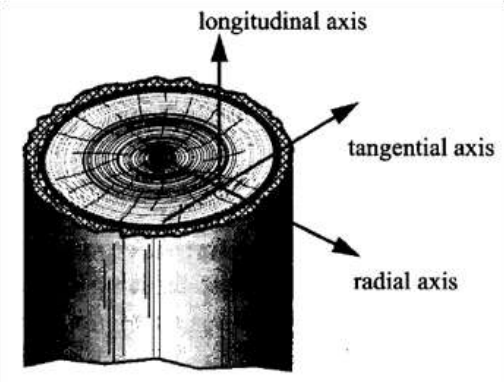
Design bending strength:

$$f_d = \frac{k_h\, k_{sys}\, k_{\mathrm{mod}}\, f_k}{\gamma_m}$$

f_d = 1.3 x 1.1 x 0.8 x 16.0 / 1.3

For beam and column, some of the structural calculation items are listed below:

- Tension & Compression (parallel to grain – longitudinal axis)
- Bearing (compression perpendicular to grain – radial axis)
- Bending
- Shear (transverse shear force) & Torsion
- Notched beams
- Combined stresses
- Member stabilities



For example: If you need to check Tension or Compression, you need to do the following calculations:

Tension & Compression (parallel to the grain)

$$\sigma_d \le f_d$$

$$f_d = \frac{k_h\, k_{sys}\, k_{\mathrm{mod}}\, f_k}{\gamma_m}$$

$$k_h = \min\left\{\left(\frac{150}{h}\right)^{0.2}, 1.3\right\} \qquad \text{EC5, P26}$$

$$\sigma_d = F_d / area$$

Please Note:

All constant factors and relevant formulas shown above are given in the relevant design codes (uploaded onto the Blackboard), you need to double check the factors and formulas.

For the items listed above for timber component (beam & column) structural design, your program should **at least** be able to conduct one item - tension or compression checking; if your program can do more, it will get extra marks for you.

Test Case: you should design some test cases to test your program. Please explain all of your test cases, the meaning you choose those test values, and use some screen shots in your report.

Your program should be able to:

- Design and implement a program to conduct Timber Structural Component design;
- Your program should be able to repeatedly asking for inputs from user;
- Your program should come with reasonable comments / explanations;
- Your report should come with flow chart, function designs etc. to further explain your "timber design tool".

Advanced part:

- Try to add graphical interfaces to your program – by any means, such as matlab / sketchup / or using visual studio;

- You program should be able to deal with data file operation, for example, to read in data from an input datafile, and output results into an output datafile;

- When your program calculates the external actions, can it deal with one-way slab or two-way slab? Can it check the structural models? (use the following information)

  BS EN 1992-1-1:2004 P57

  - Beam: length >= 3*depth
  - Slab: length (shorter) >= 5* thickness
    One-way: two sides; length ratio >=2
    Two-way: length (larger) / length (shorter) <2
  - Column:
    Section depth <=4 * width
    Height >= 3* section depth

- You can state any other advanced features that implemented in your program to earn extra marks for your coursework 1.