Deflection and preliminary vibration effects on Structural Elements

July 2012

BY PERD H. CAMILLERI

The structural strength calculations being well advanced are based on safety character-
istics. The serviceability requirements dwell-
ing on deflection, nodal vibration, and materials, after which characteristics depend on the use of the structural and its effect on the user. An agricultural shell can suffer deflections to a greater extent than the non-
load bearing partitions in a residential premise. With indented cracking that is less anticipated than the user impact may also occur on the function of a building, in the case of operating machinery.

Over the years in Structural Engineering, serviceability, deflection ratios in the range of 360 to 300, except for purlins and sheeting rails, have all been developed in various Codes of Practice. The serviceability ratio of 360 was specified for buildings which had non-load bearing partitions. Later on it was noted that 200, which was used with ratios of 500 to 800 being quoted. These ratios rely on the rigidity of the non-
load bearing partitions. Partitions of the less ductile type such as masonry or concrete block wall may develop cranes wall tilting in bathrooms should trend towards the higher ratios. It is quite necessary to explain why the cracking pattern is of such concern and that he has to learn

Table 2: Preferred service deflection criteria for steel/ timber

<table>
<thead>
<tr>
<th>Steel or timber</th>
<th>Preferred service deflection criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prestressed</td>
<td>Not to exceed 0.003</td>
</tr>
<tr>
<td>Reinforced concrete</td>
<td>Not to exceed 0.005</td>
</tr>
</tbody>
</table>

1.00 being exceeded by a structural engineer may be reduced by 0.7 for a 2 span combi-
nation, and by 0.52 for a 3 span combina-
tion. This chart can easily be updated for any span.

Deflection or vibration calculations may be di-
erating exercises in a design office.

The Eurocodes note that deflection limits should be specified for each project, after having been

differentiated to the related site. Where a more dynamic approach is needed to limit vibration from machinery, the "BREEAM" manual for steelwork design to BS1042, generally above the 360 limits men-
tioned above, explaining possibly the reason

The fundamental frequency of floors in structures to EC3 notes the following:

- The fundamental frequency of floors in dwellings and offices (EC3 - steelwork) should not be less than 5 cycles/second.
- The fundamental frequency of floors used for dancing and clubs (EC3 - steel-
work) should not be less than 5 cycles/second. The older the building the greater. Finally, the age of the building also
does not lead to distinctly perceptible vibration, whereas people taking part in a
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
dance floor or lifting weights in an aerobic gym
Deflection and preliminary vibration effects on Structural Elements

BY PERI DENS H. CAMILLERI

The structural strengths calculations being well addressed are based on safety factors - albeit the serviceability requirements dealing on deflection, rotation at supports and vibration effects. After having been discussed with the client, various National Annexes then apply, showing on how ratios are to be adopted for the particular structure. How are various span-deflection ratios developed? They are to be further noted that these span-deflection ratios sometimes relate to the total deflection, whilst on other instances relate to the deflection induced solely by the imposed loads, i.e. the dead load being possibly offset by pre-camber. The code then states that demanding to partitions, cladding and finishes will get on as soon as the deflection of the span/200 or 20mm whichever is the lesser for brittle finishes, with a span/150 or 20mm whichever lesser for non-brittle finishes. EC 2 notes that the appearance and general utility of a structure may be impaired when the calculated deflection will not be subject to permanent loads exceeds span/200. Where partitions are in contact with each other, it may be necessary to limit the deflection after construction to span/200. Furthermore, for spans other than flat roofs exceeding 7m, supporting partitions will be limited to span/200 and the space/depth ratio should be multiplied by 75%. This is specified in BS 8100 (Table 2) for spans in excess of 10m.

Should a non-load bearing partition be required, the serviceability requirement of the dead load is specified in BS 8100. Where partitions are in contact with each other, it may be necessary to limit the deflection after construction to span/200. Furthermore, for spans other than flat roofs exceeding 7m, supporting partitions will be limited to span/200 and the space/depth ratio should be multiplied by 75%. This is specified in BS 8100 (Table 2) for spans in excess of 10m.

When are deflection limits considered to be exceeded? The PCI Manual for hollow core prestressed panels states that slabs exceeding 7m, supporting partitions liable to limit the deflection after construction to span/200. Where partitions are in contact with each other, it may be necessary to limit the deflection after construction to span/200. Furthermore, for spans other than flat roofs exceeding 7m, supporting partitions will be limited to span/200 and the space/depth ratio should be multiplied by 75%. This is specified in BS 8100 (Table 2) for spans in excess of 10m.

Section 2 outlines the various deflections occurring over time. Deflection or vibration calculations may be determining exercises in a design office.

Table 1: Span-to-deflection criteria in steelwork by limiting the span to deflection ratio of 1:250. The PCI Manual for hollow core prestressed panels states that slabs exceeding 7m, supporting partitions liable to limit the deflection after construction to span/200 if the deflection exceeds L/500. The span to depth ratios quoted in Table 2, relating to this situation, is obtained directly by scaling the C value in Table 2 to 1:400. Where partitions are in contact with each other, it may be necessary to limit the deflection after construction to span/200. Furthermore, for spans other than flat roofs exceeding 7m, supporting partitions will be limited to span/200 and the space/depth ratio should be multiplied by 75%. This is specified in BS 8100 (Table 2) for spans in excess of 10m.

Table 2: Preferred span to deflection characteristics

<table>
<thead>
<tr>
<th>Span-to-depth ratio</th>
<th>C- for timber</th>
<th>C for steelwork</th>
<th>C for reinforced concrete</th>
<th>C- for masonry &amp; reinforced concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>1.5</td>
<td>1.5</td>
<td>0.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.0</td>
<td>1.5</td>
<td>0.6</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.5</td>
<td>1.5</td>
<td>0.4</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3.0</td>
<td>1.5</td>
<td>0.3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 2: Preferred span to deflection characteristics

<table>
<thead>
<tr>
<th>Span-to-depth ratio</th>
<th>C- for timber</th>
<th>C for steelwork</th>
<th>C for reinforced concrete</th>
<th>C- for masonry &amp; reinforced concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>1.5</td>
<td>1.5</td>
<td>0.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.0</td>
<td>1.5</td>
<td>0.6</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.5</td>
<td>1.5</td>
<td>0.4</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3.0</td>
<td>1.5</td>
<td>0.3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

VIBRATION TO EC3 (Steelwork) & EC5 (Timber)

Structural engineers are normally static in their calculations, applying the method outlined above will guide the structural engineer in confirming the Eurocode requirement, that deflection limits should be derived from the deflection criteria that are to be used. This may be determined from the following:

- The fundamental frequency of floors used for dynamic analysis (EC3 - steelwork) should be not less than 5 cycles/seconde.
- The fundamental frequency of floors used for dynamic analysis (EC5 - timber) should be not less than 5 cycles/seconde.
- The fundamental frequency of floors should be derived from the deflection criteria that are to be used. This may be determined from the following:


d_2 = deflection due to live load

d_1 = deflection due to dead load

d_o = deflection due to pre-camber

Where a more dynamic approach is required to limit vibrations from furniture, the EQUISVE "Manual for the design of steel building structures to EC3", notes the following:

- For domestic timber floors (EC5 - timber), the fundamental frequency is to be obtained from the following:

\[
\text{f} = \frac{\delta}{\text{span}}
\]

where \( \delta \) is the deflection at the span. The fundamental frequency is to be obtained from the following:

\[
\text{f} = \frac{\delta}{\text{span}}
\]