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SMART Portal

Designing agricultural building frames to
the 2013 edition of BS 5502-22



Revision history

Date	Version	Description	Author
15/09/2014	1.0	Initial version	RCH

Contents

1	Introduction	1
2	Relevant BS 5502-22 clauses.....	1
3	Example – single span class 2 building frame	5

1 Introduction

BS 5502-22:2003+A1:2013 provides (inter alia) guidance to modify the main structural codes of practice to take into account the perceived lower risks and consequences of failure for many types of farm building. It also includes information on loadings which are particular to agricultural buildings. The main provisions of the code are summarised and briefly discussed in section 2 below. Section 3 shows how these may be entered in SMART Portal 2D and 3D and if required incorporated into a template file for re-use.

The current (2013) edition of BS 5502-22 achieves a very welcome major simplification of the 2003 edition eliminating a number of anomalies. Unfortunately it also replaces references to British Standards with references to the structural Eurocodes and other ENs which may be unwelcome to many engineers. However there is no logical (as distinct from political) reason why the changed code may not be used in conjunction with the equivalent British Standards especially as the resulting design outcomes will be either similar or more conservative. Pending the release of the Eurocode version of CADS SMART Portal software it is assumed that for the time being, users will use BS 5502-22+A1:2013 in conjunction with BS 5950-1:2000, BS 6399-1, 2 and 3 and this temporary guide has been prepared accordingly.

This guide has been prepared with appropriate professional engineering logic and care but it has no official status and its interpretation and application is the responsibility of the user.

2 Relevant BS 5502-22 clauses

The following commentary deals with the main issues. If in doubt reference should be made to BS 5502-22:2003+A1:2013 itself.

14.0 Design classification

In the 2013 edition of BS 5502-22, two classifications are given related to the frequency of human occupancy, and the distance to highway or human habitation as well as the intended design life. The 2003 edition had four classes with consequent complexity.

Class 1 is in effect normal building standards. Minimum design life 50 years.

Class 2 is the most common class of farm building.

In order to qualify for class 2 the following conditions must be satisfied:

- ✓ Maximum human occupancy within zone of effect:- 1 person per 100 m² for maximum 6 hours per day and up to 10 persons at any one time. Clause 14.2 allows a relaxation for short periods of higher occupancy.
- ✓ Minimum distance to human habitation or classified highway 10 m.
- ✓ Minimum design life 20 years.
- ✓ Single storey with no mezzanine floor occupying greater than 50% of ground floor area.
- ✓ No non-environmental loading. Structures retaining materials such as grain or silage must be designed as class 1.

15.2 Wind loads

BS 5502:2003+A1:2013 refers to BS EN 1991-1-4 for calculation of wind loads. However there is no logical reason why BS 6399-2 may not be used as they follow similar principles and produce similar results.

Although not mentioned, it is essential to use the EN 1991-1-4 in compliance with its UK National application document when working in the UK.

Although not specifically stated, the design life for wind may be taken into account by multiplying the 50 year peak velocity v_p obtained from the UK NA to BS EN 1991-1-4 or the 50 year effective wind speed V_e from BS 6399-2 by the following probability factors:-

Class	Design life	Factor S_p
1	50 years	1.000
2	20 years	0.946

These values have been obtained using Equation D1 of Annexe D of BS 6399-2:1997.

The same values are applicable to BS EN 1991-1-4.

It is not clear whether the above S_p factor is implicit in the load classification factor given in 16.1.2 (see below) or may be applied as well. Until this has been clarified it may be prudent to assume $S_p = 1.0$ in all cases.

15.3 Imposed roof loads other than wind loads

15.3.1 Modifications to imposed roof loads derived from BS EN 1991-1-1

15.3.1.1 Minimum roof imposed loads

Clause 15.3.1.1 states that for class 1 agricultural buildings with no access to the roof other than for maintenance and repair, the roof imposed load on plan should be as defined in Table NA.7 of the UK NA to BS EN 1991-1-1 which is the same as clause 4.3.1(c) of BS 6399-3 ie:-

- ▶ 0.60 kN/m^2 for roof slopes up to 30°
- ▶ zero for roof slopes greater than 60°
- ▶ $0.6 [(60 - \text{roof slope})] \text{ kN/m}^2$ for roof slopes between 30° and 60°
- ▶ or a concentrated load of 0.9 kN (not usually relevant to frame analysis.)

Most new agricultural buildings have roof slopes less than 30° so generally the imposed load on plan is 0.60 kN/m^2 for class 1 buildings.

For class 2 agricultural buildings with no access to the roof other than for maintenance and repair, clause 15.3.1.1 requires that the minimum roof imposed load may be taken as no greater than 0.40

kN/m^2 as per BS EN 1991-1-1. The National Annexe is not mentioned. This would appear to imply a uniform load on plan of 0.40 kN/m^2

15.3.1.2 Snow loads

This clause states that snow loads should be obtained from BS EN 1991-1-3 and the UK NA thereto. The resultant figures are not significantly different from those obtained from BS 6399-3 so pending the introduction of software support for the Eurocode it is proposed to refer to BS 6399-3.

15.4 Floor loads

In this section BS 5502 gives extensive useful information on floor loadings for agricultural applications. However suspended floors are rarely encountered in the design of steel portal frames for agriculture use so they are not considered further in this document.

15.5 Wall loads

This section is concerned with lateral loads on containment walls due to storage of materials.

15.5.1 Walls for storage areas

This clause simply states that loads should be calculated using recognised earth pressure theories and so is not specific to agricultural buildings. However reference may be made to Table 5 for densities and angles of repose for common materials and to BS EN 1991-4:2006 especially section 5.4 and Annexes A and E for calculation of pressure. For silage reference should be made to 15.6

15.6 Loads on bunkers and clamps for the storage of grass silage

15.6.2 Surcharging of silage

This clause details the conditions in which silage may be surcharged without invalidating the loadings in clause 15.6.3.

15.6.3 Loads on retaining walls

This clause and Table 6 specifies the lateral loads to be assumed in the design of walls to sustain grass silage storage and mechanical compaction consisting of:

		Height up to 8m		Height 8 to 10 m	
Uniform lateral pressure	W_g	3.9	kN/m^2	4.5	kN/m^2
Pressure varying linearly with depth z	$T_g z$	$3.9z$	kN/m^2	$4.5z$	kN/m^2
Two concentrated horizontal loads	P_g	4.0	kN	5.0	kN

The concentrated loads are applied 0.6 m below the surface of the silage and at 2.0 m centres. The loads may be applied as patch loads on areas $0.6 \text{ m} \times 0.6 \text{ m}$ for wall panel design but point loads are sufficiently accurate for frame design.

16 Structural design (materials)

16.1.1 Design

This clause states: “Designs should conform to the relevant Eurocodes covering the structural materials being used, modified for classified agricultural buildings and structures in accordance with 16.1.2 and 16.1.3. Design loads should be obtained by combining the classified loads and multiplying them by the appropriate partial safety and combination factors obtained from BS EN 1990:2002+A1:2005 Annex A1.”

There seems to be no logical reason why British Standards should not be substituted for Eurocodes in the above. The partial safety factors in the relevant British Standards already incorporate load combination factors.

16.1.2 Classified loads

BS 5502-22:2013 Table 7 gives classification factors (γ_c) to be applied to the characteristic loads to obtain ‘classified loads’ for design:-

Class 1:	1.00
Class 2:	0.90

It seems to be unreasonable to apply the classification factor to dead loads and frame self-weight because these can be determined accurately and should not be reduced especially in load combinations where they act ‘adversely’.

Where the software generates imposed, snow and wind loads together with load categories and combinations (as in SMART Portal) users may find it convenient to apply the classification factor for class 2 structures to the partial safety factors rather than to the loads themselves

Note that BS 5502-22 makes no mention of control of deflection for the serviceability limit state. It is presumably left to the designer’s judgement as to whether to check and limit deflections.

If SLS checks are made it might be considered reasonable to apply the ‘classification factors’ listed above instead of the usual 1.00. However it is simpler to keep the analysis unchanged and modify the deflection limits as considered appropriate.

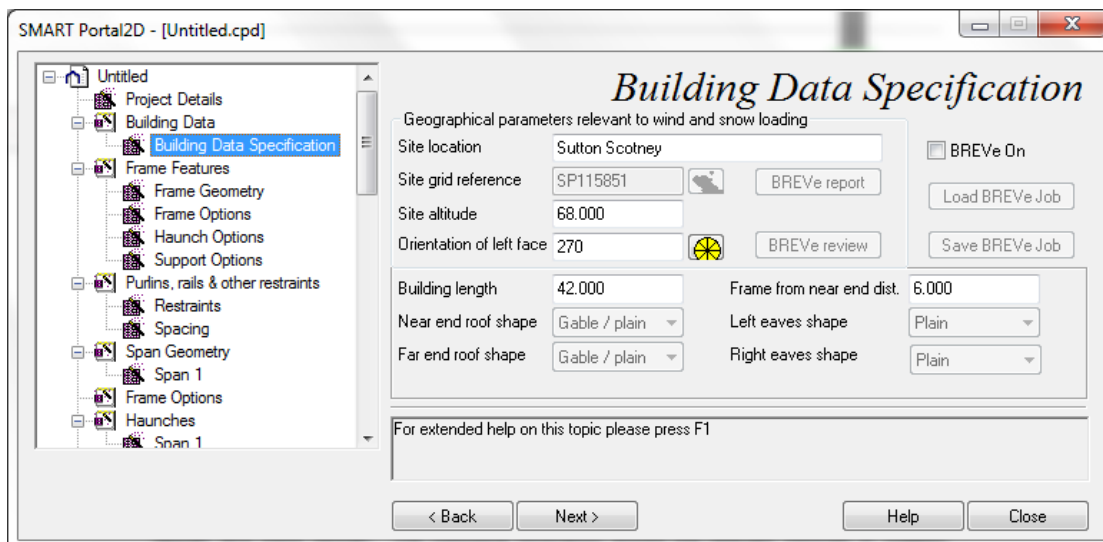
Summary of adjustments for using BS 5502-22:13 with BS 5950-1:2000

[Applying the classification factor to the partial safety factors instead of the loads]

Classified ULS partial safety factors	BS 5502 class 1	BS 5502 class 2
Dead load with imposed only	1.40	1.26
Dead load (beneficial eg: with wind uplift)	1.00	1.00
Dead with wind and imposed	1.20	1.08
Imposed or snow with dead only	1.60	1.44
Imposed or snow with dead and wind	1.20	1.08
Wind with dead only	1.40	1.26
Wind with imposed or snow	1.20	1.08
Minimum roof imposed load	0.60	0.40 kN/m ²
SLS deflection limits	At designer's discretion / client requirements.	

3 Example – single span class 2 building frame

The example is a single 20 m span duopitch portal 42 m long in 6m bays, 5m to eaves with 12.5 degree roof pitch. SMART Portal 2D is used but the sequence is similar for SP3D.

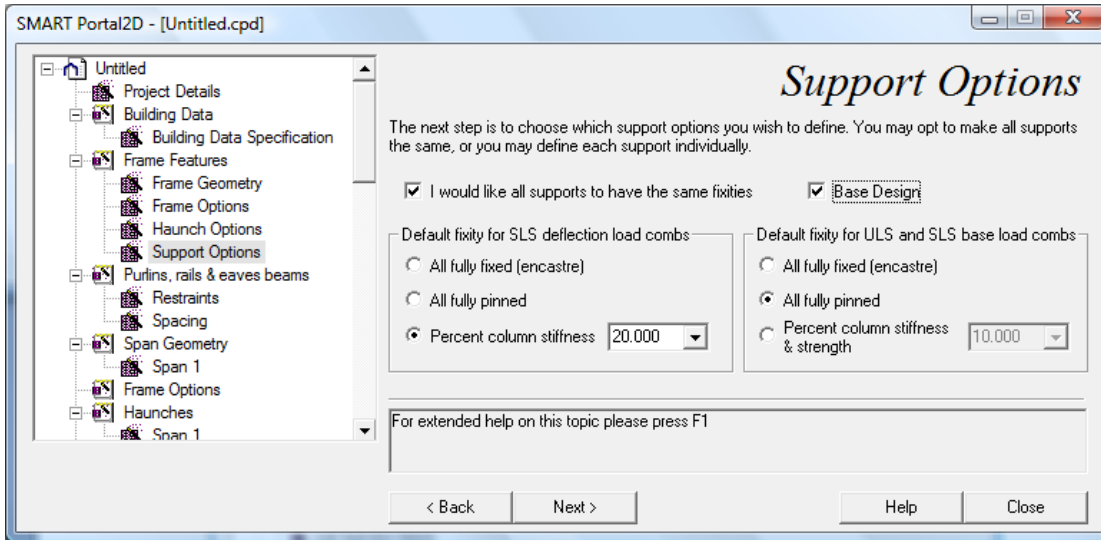


The illustration above shows the *Building data* page for a site in rural Hampshire. Note that the link to BREVe wind software is no longer available and is therefore disabled. Pending the release of CADs new wind software the relevant data may be obtained from a stand-alone copy of BREVe or by manual interpretation of BS 6399-2 as outlined below.

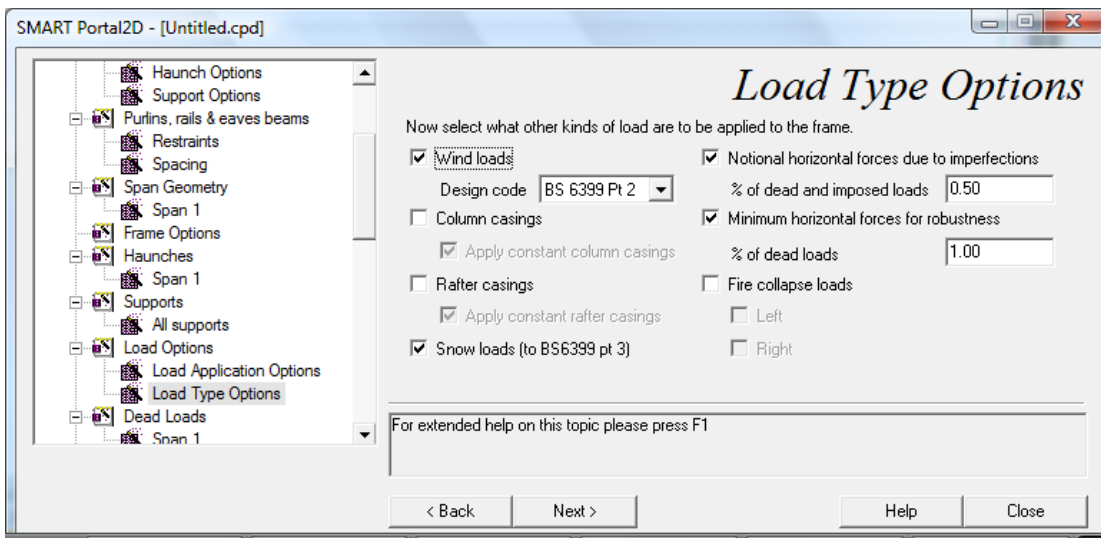
In order to produce a competitive design it is usually necessary to take full advantage of the provisions for 'nominally pinned bases' in BS 5950-1 clause 5.1.3.3. This allows partial fixity

SMART Portal: Designing agricultural building frames

equivalent to 20% of the column stiffness to be assumed for the purpose of calculating deflections under SLS load combinations whilst assuming pinned conditions for ULS frame design and base design. The following illustration shows the relevant settings in *Support options* page:-

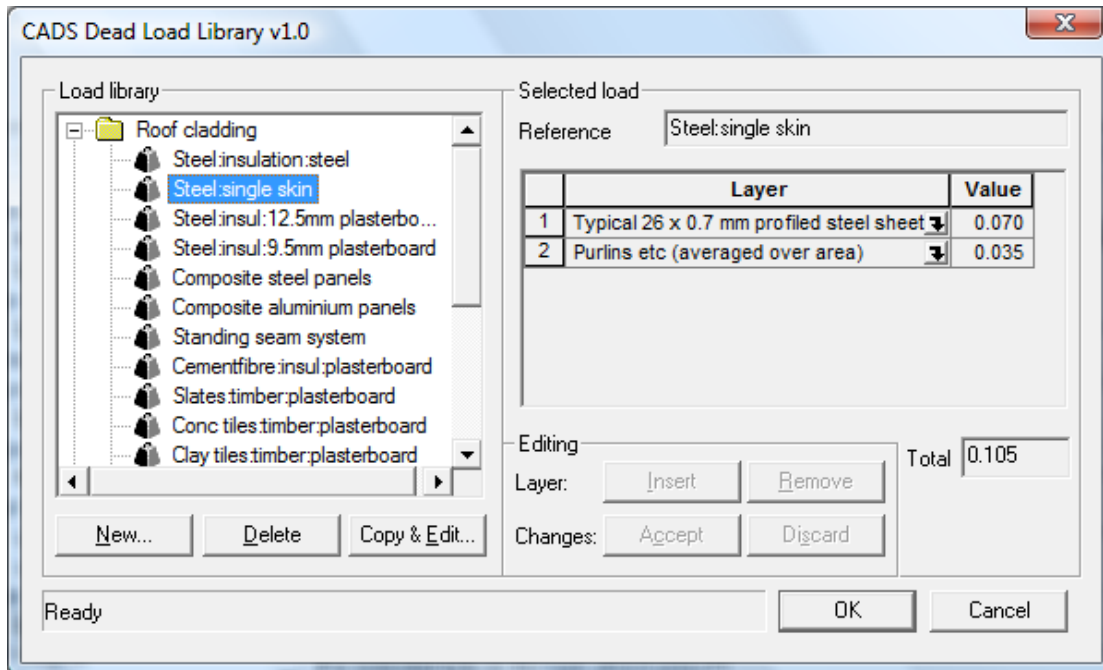


In *Load type options* page the default settings are adopted:-

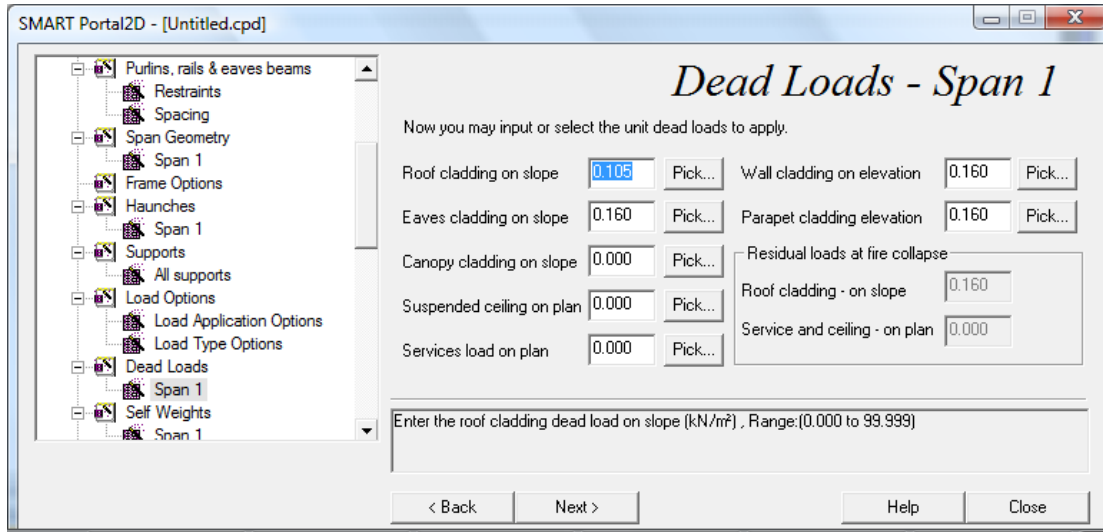


SMART Portal: Designing agricultural building frames

In the *Dead loads* page for the *Roof cladding on slope* input, either enter a known value or select [...] to open the dead loads library to perhaps select a single skin steel sheeting type and purlins as shown below:-

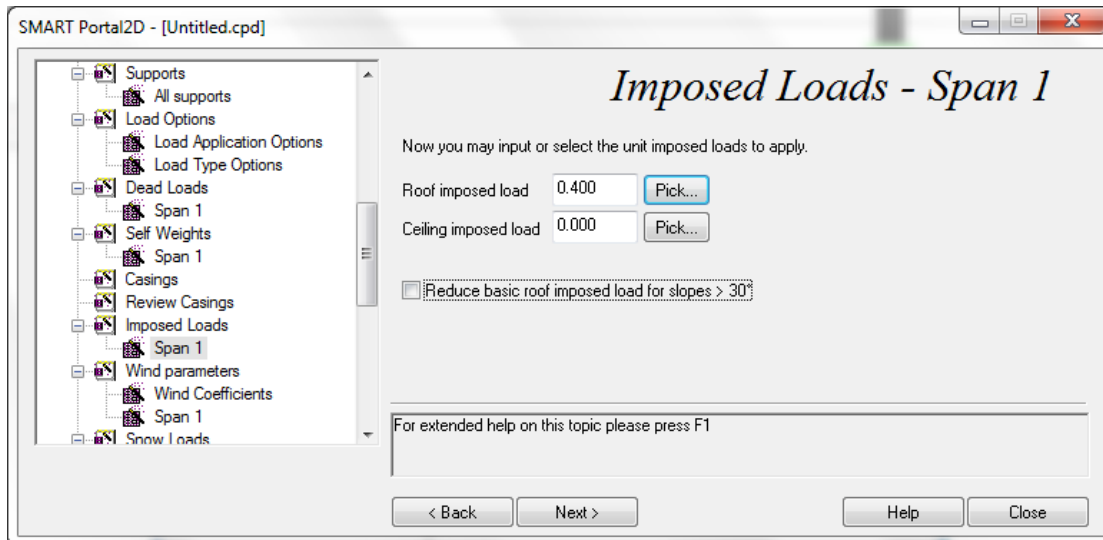


Press OK to return the unit load value to the *Dead loads* page. For this example we will assume that there is no suspended ceiling or allowance for services. The other values are not used for a simple shed so can be left as defaulted. The resultant page is shown below:-

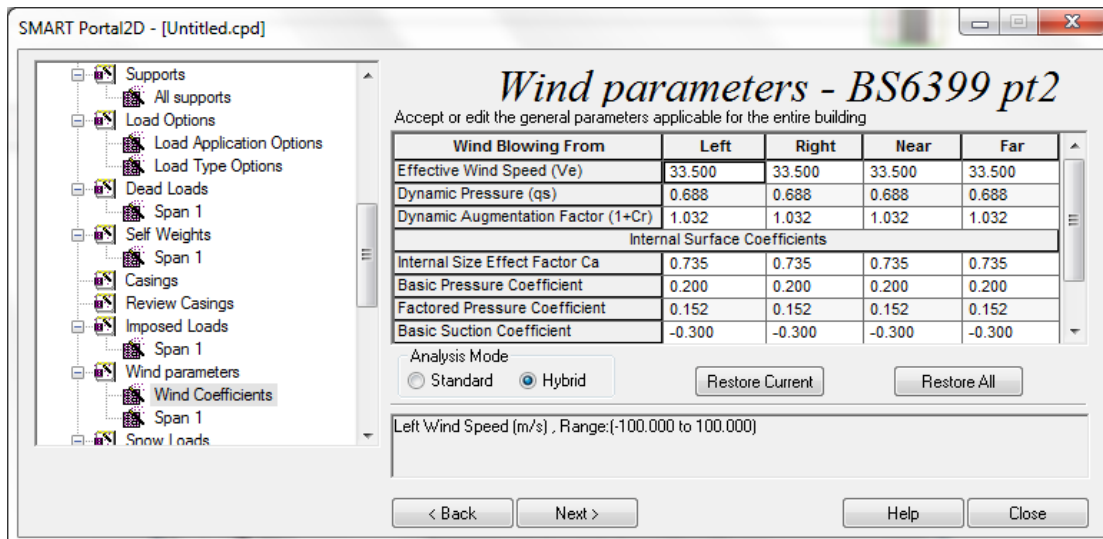


SMART Portal: Designing agricultural building frames

In the *Imposed loads* page enter the minimum imposed roof load required by BS 5502-22 clause 15.3.1.1:-

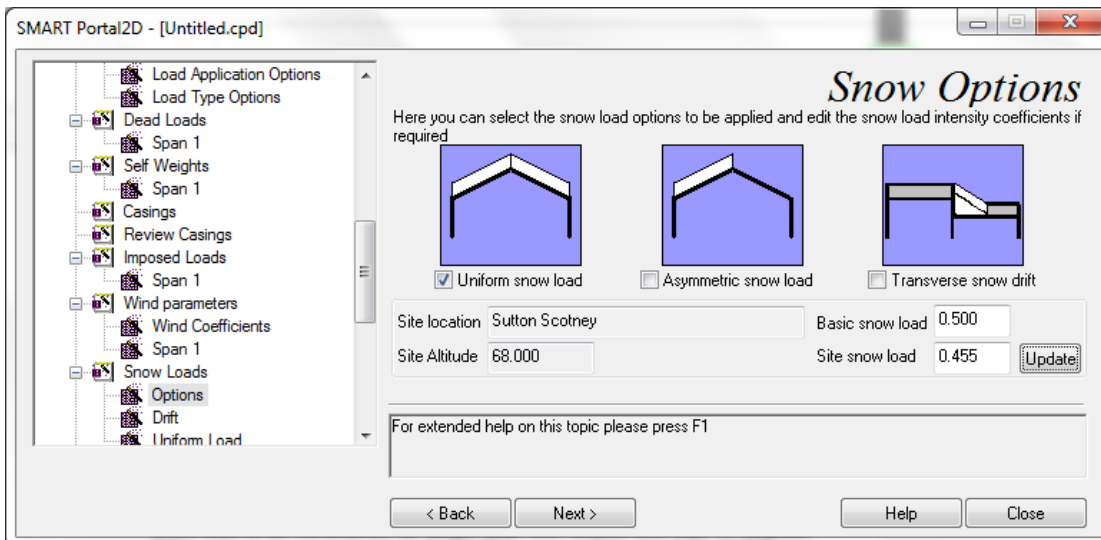


In the *Wind parameters*>*Wind coefficients* page, the wind speeds obtained for the site are entered:-



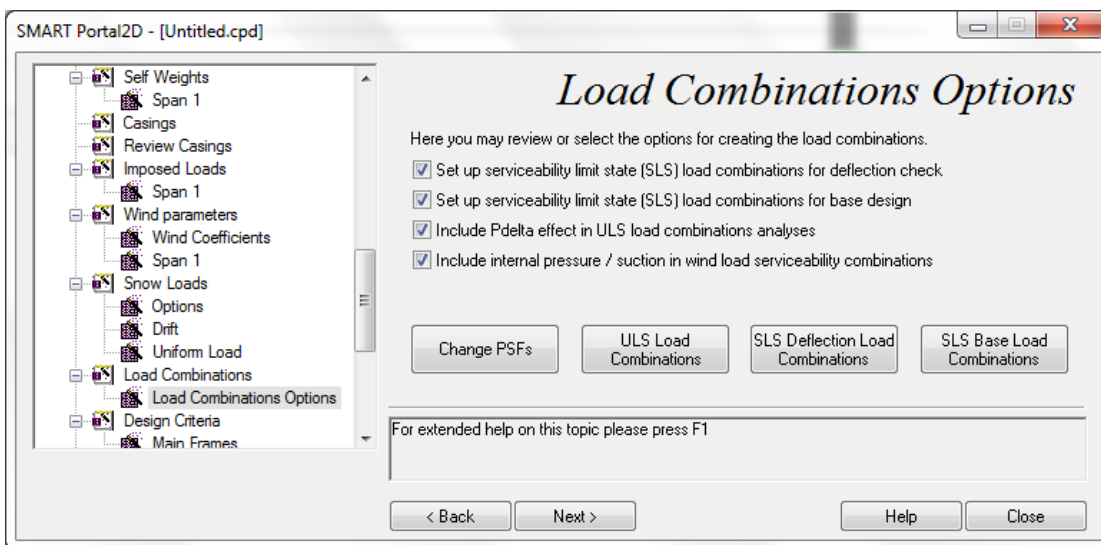
In this example the effective wind speed for the most unfavourable direction has been entered for all four directions. In some circumstances it may be advantageous to calculate separate wind speeds for each direction.

In this page you can also make any changes to the basic internal pressure and suction coefficients that may be appropriate for dominant openings etc. Refer to BS 6399-2 and explanatory texts for guidance.



In the *Snow loads > Options* page, select uniform snow load because it must be designed for as the minimum imposed load is low. From BS 6399-3 figure 1, the basic snow on the ground loading at the example site may be estimated as 0.5 kN/m². Press *Update* to display the site snow load 0.455 adjusted for altitude. Note that BS 6399-3 does not require asymmetric snow load to be considered for single span roof slopes less than 15 degrees.

In the *Load combinations options* page shown below, press *Change PSFs*.



Partial Safety Factors For Ultimate Limit State Analyses X

Here you may select the design code governing the values of partial safety factors to be applied to the characteristic or working loads or select 'User defined' to edit the values.

Design code for partial safety factors and load combinations: BS 5950 pt1 ▼

Dead load			
Beneficial	<input type="text" value="1.000"/>	Adverse with imposed & crane loads	<input type="text" value="1.200"/>
Adverse with imposed load	<input type="text" value="1.400"/>	Adverse with wind & crane loads	<input type="text" value="1.200"/>
Adverse with imposed & wind load	<input type="text" value="1.200"/>	Fire collapse load	<input type="text" value="1.000"/>
Adverse with crane loads	<input type="text" value="1.400"/>		
Imposed load			
Beneficial	<input type="text" value="0.000"/>	Adverse with dead & wind load	<input type="text" value="1.200"/>
Adverse with dead load	<input type="text" value="1.600"/>	Adverse with crane loads	<input type="text" value="1.200"/>
Wind load			
With dead load only	<input type="text" value="1.400"/>	Adverse with crane loads	<input type="text" value="1.200"/>
With imposed & dead load	<input type="text" value="1.200"/>	Wind load with fire load	<input type="text" value="0.330"/>
Crane loads			
Vertical	<input type="text" value="1.600"/>	With imposed loads	<input type="text" value="1.200"/>
Horizontal	<input type="text" value="1.600"/>	With wind loads	<input type="text" value="1.200"/>
Combined	<input type="text" value="1.400"/>		
Others			
Exceptional snow (drift) loads	<input type="text" value="1.050"/>		

The Partial safety factors page opens with the standard BS 5950 values displayed but 'greyed out'. Change the *Design code...* option to *User defined* to allow editing to the reduced 'classified partial safety factors' implied by BS 5502-22 for class 2 buildings as shown below. Please note that these values are our interpretation of BS 5502. They are not specifically stated in the code and so adoption is at the user's discretion.

Partial Safety Factors For Ultimate Limit State Analyses X

Here you may select the design code governing the values of partial safety factors to be applied to the characteristic or working loads or select 'User defined' to edit the values.

Design code for partial safety factors and load combinations: User defined ▼

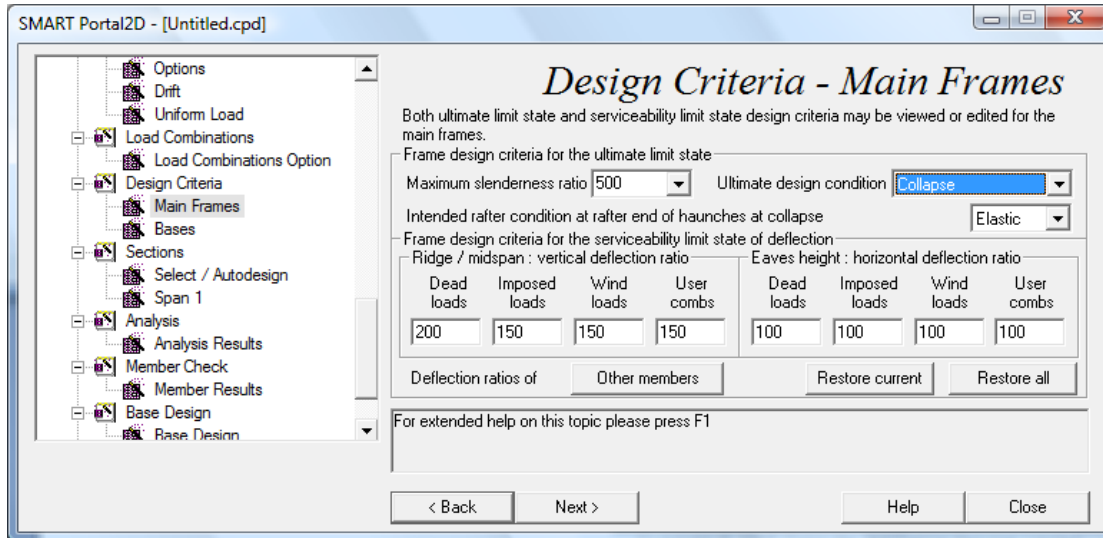
Dead load			
Beneficial	1.000	Adverse with imposed & crane loads	1.200
Adverse with imposed load	1.260	Adverse with wind & crane loads	1.200
Adverse with imposed & wind load	1.080	Fire collapse load	1.000
Adverse with crane loads	1.400		
Imposed load			
Beneficial	0.000	Adverse with dead & wind load	1.080
Adverse with dead load	1.440	Adverse with crane loads	1.200
Wind load			
With dead load only	1.260	Adverse with crane loads	1.200
With imposed & dead load	1.080	Wind load with fire load	0.330
Crane loads			
Vertical	1.600	With imposed loads	1.200
Horizontal	1.600	With wind loads	1.200
Combined	1.400		
Others			
Exceptional snow (drift) loads	1.050		

Snow load , Range:(1.000 to 2.000) Cancel OK

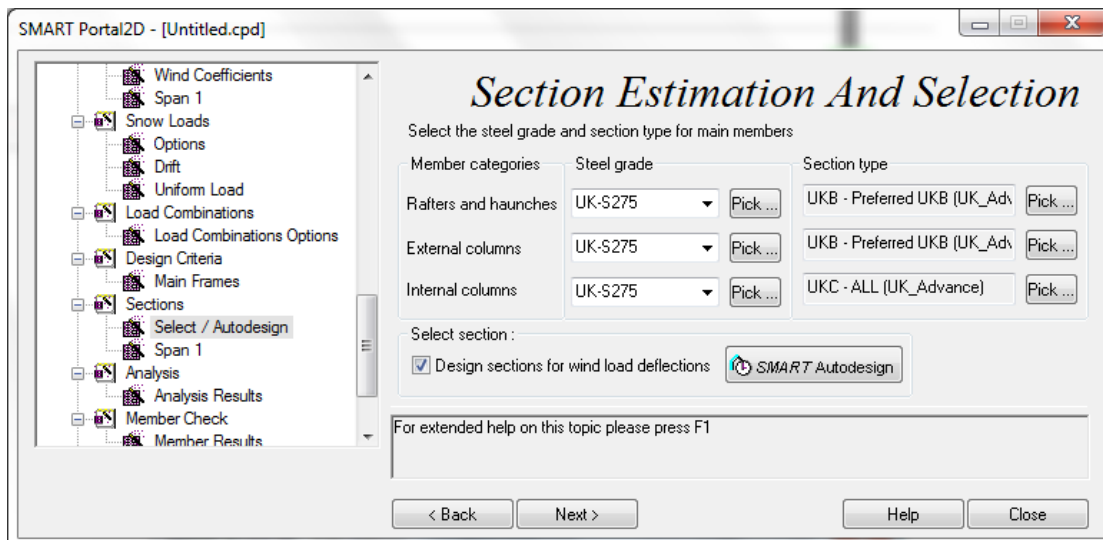
Select OK to return to the *Load combinations options* page. The resulting load combination tables can be viewed by pressing *ULS load combinations*. When you are satisfied with the load combinations select *Next* to move to the *Design criteria > Main frames* page. This opens with the usual default values. For most agricultural building frames with pin bases the default minimum eaves height to horizontal deflection ratio under wind loading will control the design. Even with nominal partial fixity this is likely to be the case. To achieve a competitive design it is necessary to carefully consider what deflection limits are appropriate or acceptable for severe storm conditions. For the example frame with eaves node height 5000 mm above foundation, $H/200 = 25$ mm, $H/100 = 50$ mm and $H/50 = 100$ mm. There is no official guidance for this but one could contemplate $H/50$ perhaps for a remote barn at one extreme whilst $H/200$ or even $H/300$ may be required for more conventional buildings. It may be appropriate to explain the issues and cost implications to the client and reach an informed agreement. CADS SMART Portal enables comparative designs to be prepared and costed very quickly so that the cost/benefits can be assessed.

SMART Portal: Designing agricultural building frames

The illustration below shows the design criteria settings for a moderately competitive / permissive design.

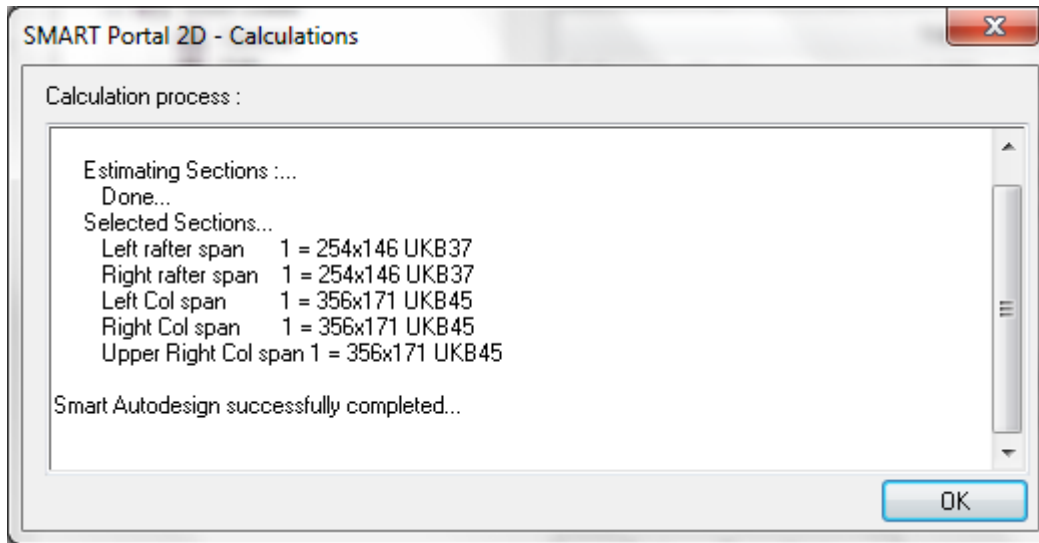


The *Select/Autodesign* page can be used to choose grade of steel, section list etc before proceeding to autodesign:

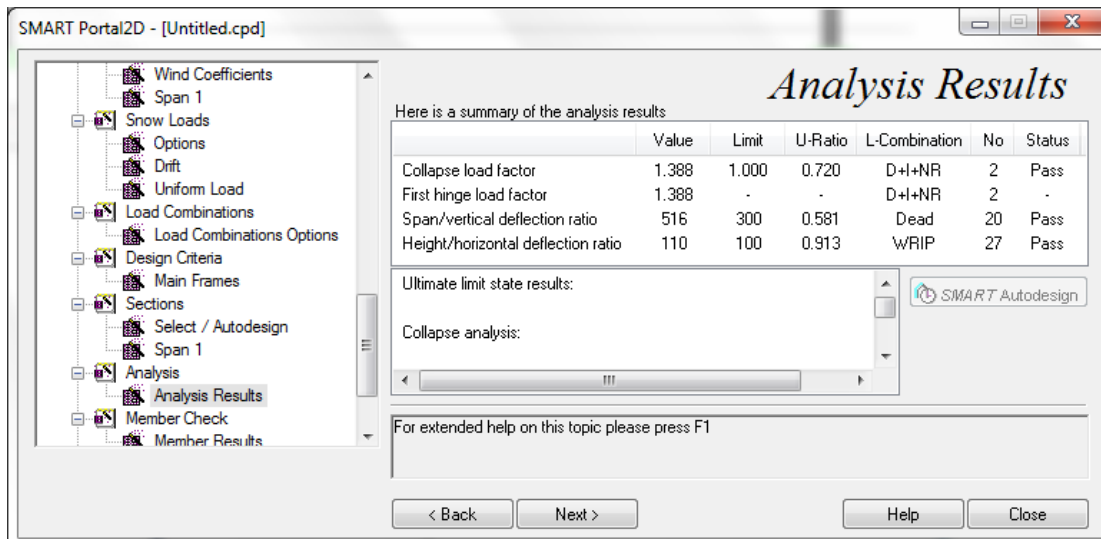


SMART Portal: Designing agricultural building frames

Autodesign produces the following sections for the given criteria:-



And analysis results summary as shown below



It will be noted that horizontal deflection still controls and the frame is moderately over-designed for strength.

When you are satisfied with your settings you can save them as a template for use in similar circumstances. Select *File > Save as template* to create a .cpt or .spt file which will be stored in theSP2D\Data\Templates file or any alternative location you choose. Choose a suitable filename like "BS 5502 class 2.cpt". On starting a new job, if the required template file does not appear in the drop-down menu of templates it can be found using the browser [...] button.