

CUSTOMER SUPPORT NOTE

Smart Combinations and Envelopes

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This support note is issued as a guideline only.



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1. Introduction

This technical note explains how *Smart Combinations* and *Envelopes* function in LUSAS. These tools have been improved, with the updates available from version 24 onwards. The improved tools simplify post-processing by removing duplication and offering a clearer, more intuitive interface.

Results retrieved using the *Print Results Wizard* facility can be inspected by right-clicking on values of interest and selecting the *Examine Calculations* option. This feature is used in this support note to review results from combinations and envelopes.

2. Smart Combinations

2.1 Definition

Smart Combinations allow results from individual loadcases – if needed from multiple analyses – as well as from *Basic Combinations*, other *Smart Combinations*, or *Envelopes*, to be multiplied by a beneficial or adverse factor and then combined. Loadcases are classified as permanent or variable.

There are two combination modes: the *Leading and accompanying actions* mode and the *Standard* mode. In both modes, beneficial and adverse factors must be defined for permanent loadcases. For variable loadcases, only adverse factors are required, as a beneficial factor of zero is assumed by default.

When the *Leading and accompanying actions* mode is selected – following the Eurocode approach in which one variable action is treated as the leading action while all other variable actions are considered as accompanying actions with reduced effects (unless those effects are beneficial) – combination factors must also be specified for variable loadcases.

2.2 Example – Smart Combinations

2.2.1 Standard mode

The smart combination shown in Figure 1 is considered in this example. The *Standard* mode is selected. All variable loadcases are included, as the option to limit their number is disabled.

Smart Combination

Combination mode: Standard Limit the number of variable loadcases considered 0

Available

Filter...

- Deck Major Bending Mx (Mx) ~
 - 93:Inspection Points - Deck Maj
 - 94:Inspection Points - Deck Maj
 - 95:Inspection Points - Deck Maj
- Deck Major Bending Mx (Mx) ~
 - 96:Inspection Points - Deck Maj
 - 97:Inspection Points - Deck Maj
 - 98:Inspection Points - Deck Maj
- Post processing
 - VLO Run 1
 - 71:VLO Run 1 ~ Characteristic-gr1a
 - 72:VLO Run 1 ~ Characteristic-gr1b
 - 73:VLO Run 1 ~ Characteristic-GR4
 - 74:VLO Run 1 ~ Characteristic-GR5
 - 75:VLO Run 1 ~ Combination-gr1a
 - 76:VLO Run 1 ~ Frequent-gr1a
 - 77:VLO Run 1 ~ Frequent-gr1b
 - 29:Temperature Converted
 - 23:Settlement Env Converted
 - 25:Temp Annual Env Converted
 - 27:Temp Daily Env Converted
 - 31:Wind Env Converted
 - 33:Braking Env Converted
 - 35:Horizontal Env Converted
 - 37:Accidental Env Converted

Permanent loadcases

ID	Name	Beneficial factor	Adverse factor
1	Gravity	1	1.35
2	Parapet Loads	0.8	1.2
3	Surfacing	1	1.2
23	Settlement Env Converted	1	1.2

Variable loadcases

ID	Name	Adverse factor
71	VLO Run 1 ~ Characteristic-gr1a	1.5
29	Temperature Converted	1.5
31	Wind Env Converted	1.5

Step 1

Figure 1 – Smart combination – Standard mode.

The maximum result is presented in Figure 2. The *Examine Calculations* feature clearly shows the contribution of each loadcase, facilitating verification.

The calculation can be broken down as follows:

- The unfactored results of the permanent loadcases are evaluated to determine whether the beneficial or adverse factors are to be applied. Since the maximum result is required, the adverse factors are applied to the positive results, and the beneficial factor to the negative result.
- The adverse factors are applied to the variable loadcases, as their effects are positive.

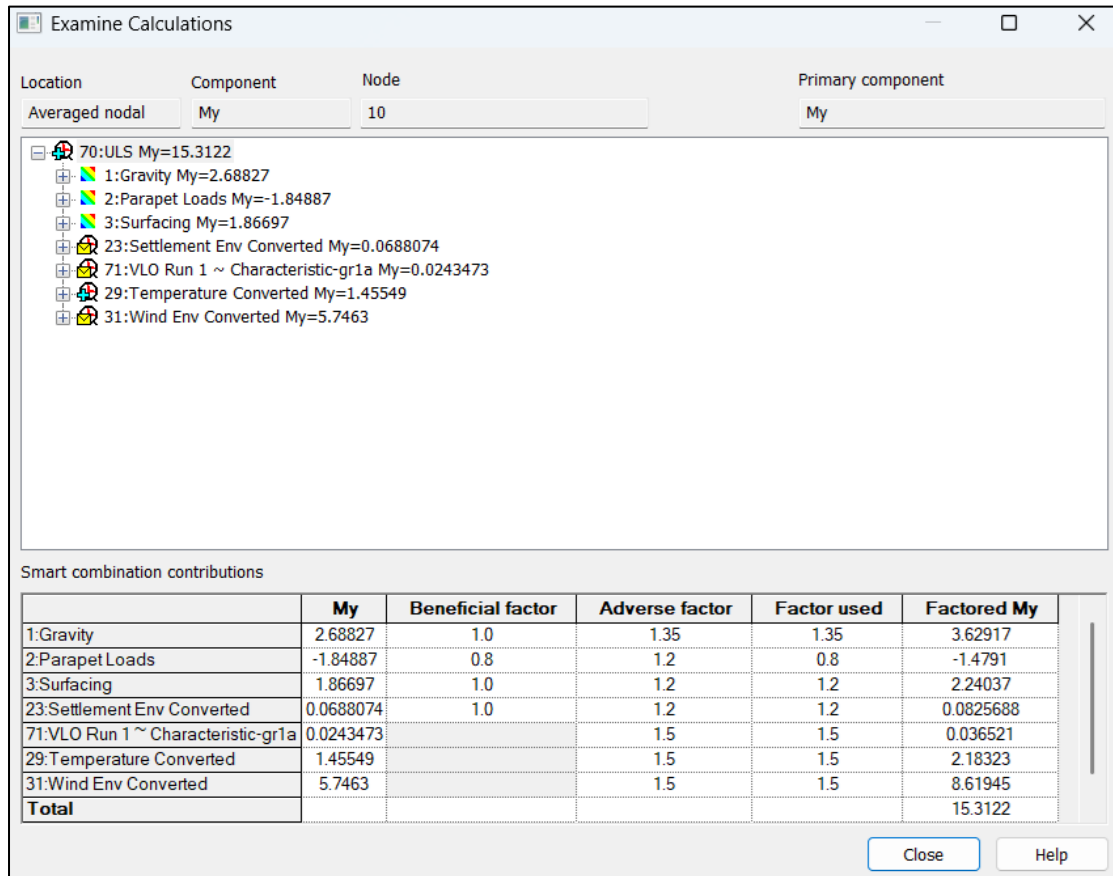


Figure 2 – Smart combination – Standard mode – Maximum result.

2.2.2 Leading and accompanying actions mode

When the mode is set to *Leading and accompanying actions*, as shown in Figure 3, combination factors must be specified as well. In this example, all variable loadcases have a combination factor of 0.70. Additionally, all variable loadcases are included, as the option to limit their number is disabled. The maximum result is presented in Figure 4.

The calculation can be broken down as follows:

- The unfactored results of the permanent loadcases are evaluated to determine whether the beneficial or adverse factors are to be applied. Since the maximum result is required, the adverse factors are applied to the positive results, and the beneficial factor to the negative result.
- The unfactored results of the variable loadcases are multiplied by their respective adverse factors to determine which loadcase produces the maximum result. This loadcase is considered the leading loadcase, and its unfactored result is multiplied only by the corresponding adverse factor. The unfactored results of the remaining variable loadcases that produce positive effects are multiplied by their respective adverse and combination factors.

The same principle applies when minimum results, rather than maximum results, are required.

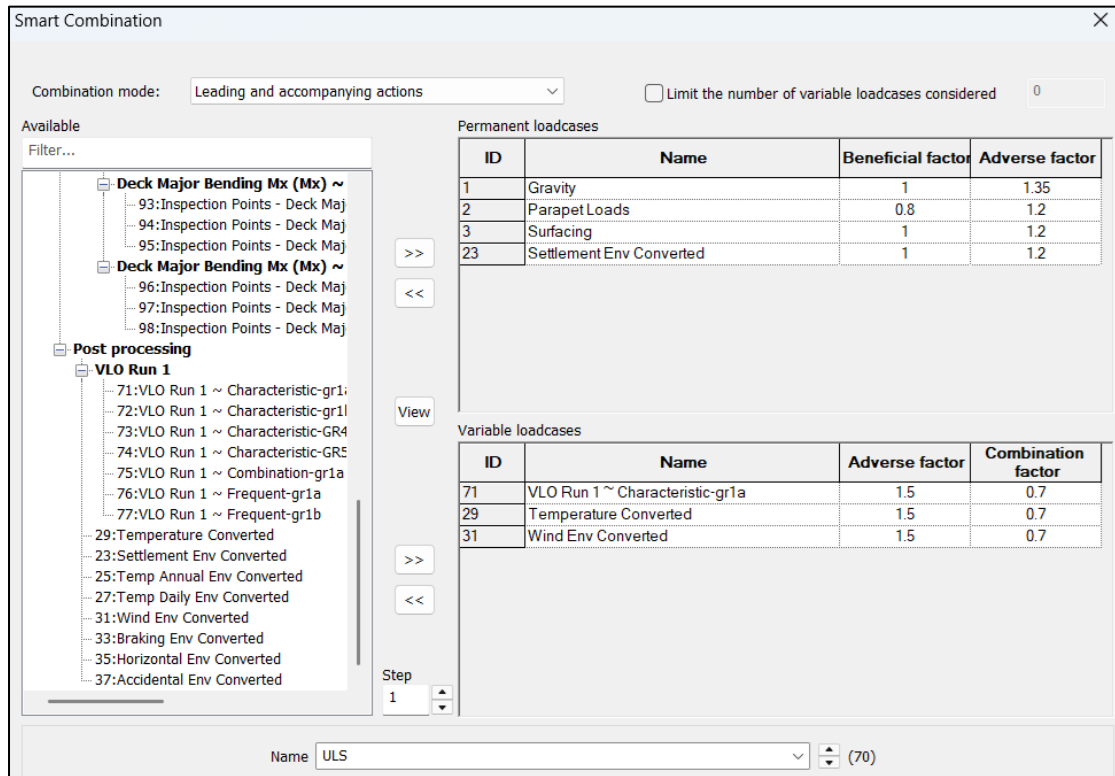


Figure 3 – Smart combination – Leading and accompanying actions mode.

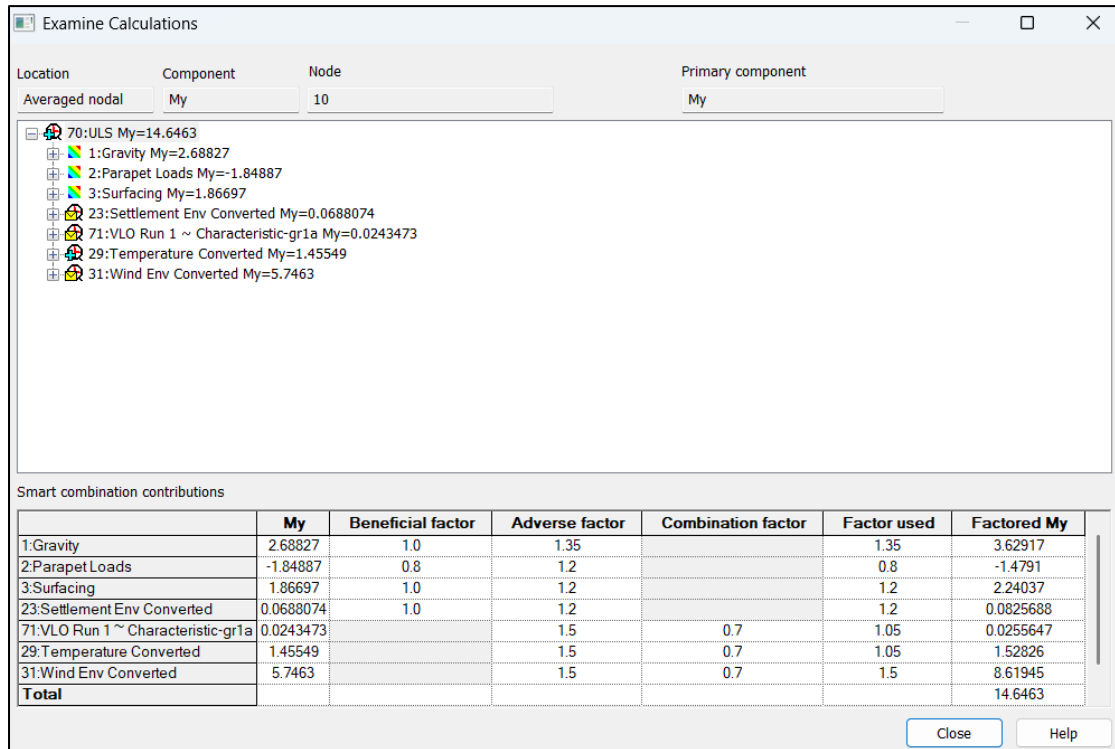


Figure 4 – Smart combination – Leading and accompanying actions mode – Maximum result.

For codes that adopt an approach similar to Eurocode, based on leading and accompanying actions, the *Leading and accompanying actions* mode is more efficient than the *Standard* mode because it automatically determines the leading variable action at each location. In contrast, the *Standard* mode requires a separate load combination for each variable action that may be

the leading action. As a result, a larger number of combinations is required, increasing computation time.

3. Envelopes

3.1 Definition

Envelopes allow the maximum and minimum results from individual loadcases – if needed from multiple analyses – as well as from *Basic Combinations*, *Smart Combinations*, or other *Envelopes*, to be determined.

3.2 Example – Envelopes

In this example, an envelope comprising four loadcases is considered. The *Examine Calculations* dialog (Figure 5) provides a summary of all considered values, clearly highlighting the loadcase that produces the minimum result.

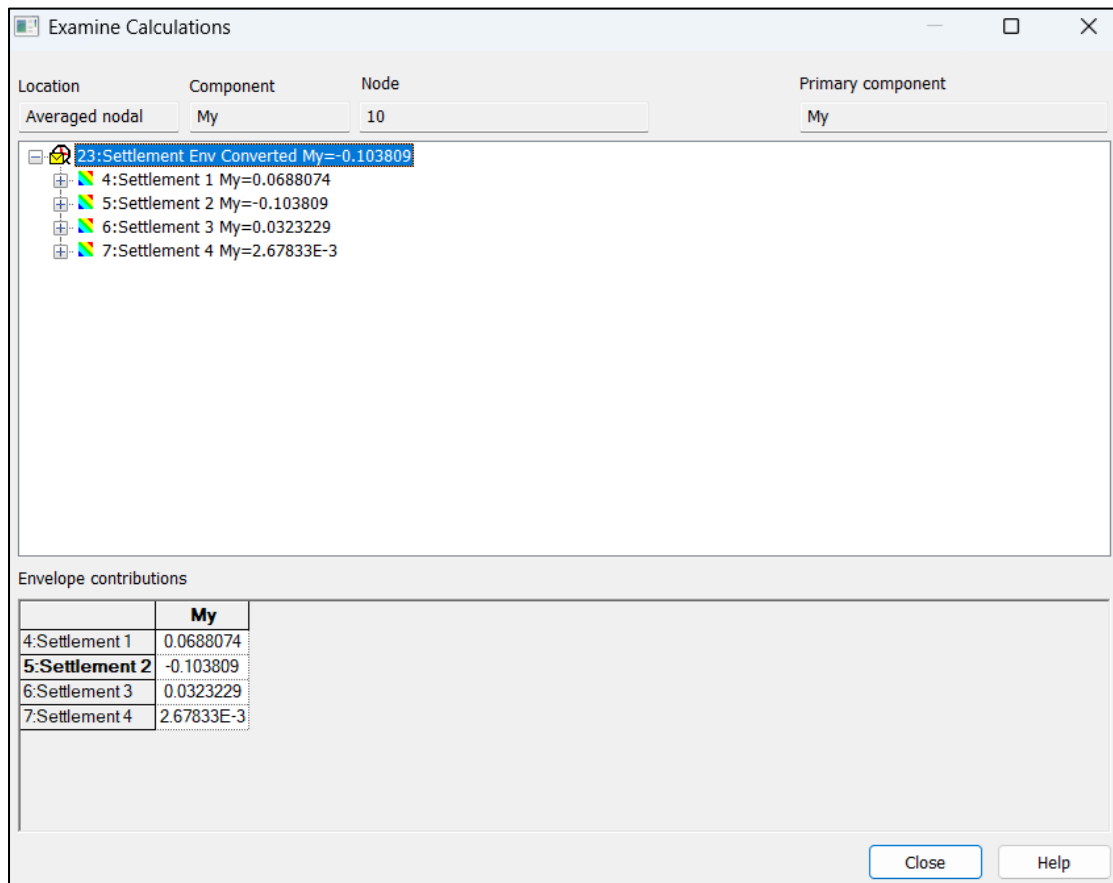


Figure 5 – Envelope – Minimum result.

4. Nested Smart Combinations and Envelopes

4.1 Definition

Envelopes and *Smart Combinations* may include other *Envelopes* and *Smart Combinations*. The same rules apply when *Envelopes* or *Smart Combinations* are nested. However, as the number of nested *Envelopes* or *Smart Combinations* grows, calculations may take longer.

4.2 Example – Nested Smart Combinations and Envelopes

In this example, the combination shown in Figure 3 is examined. It includes three individual loadcases (1, 2, and 3), three envelopes (23, 31, and 71), and one smart combination (29). Figure 6 shows the contribution of each loadcase, along with the minimum result. The symbols

in the *Examine Calculations* dialog indicate whether a loadcase is an individual loadcase, an envelope, or a smart combination. The contribution of smart combination 29 is obtained from the combined contributions of the envelopes it includes.

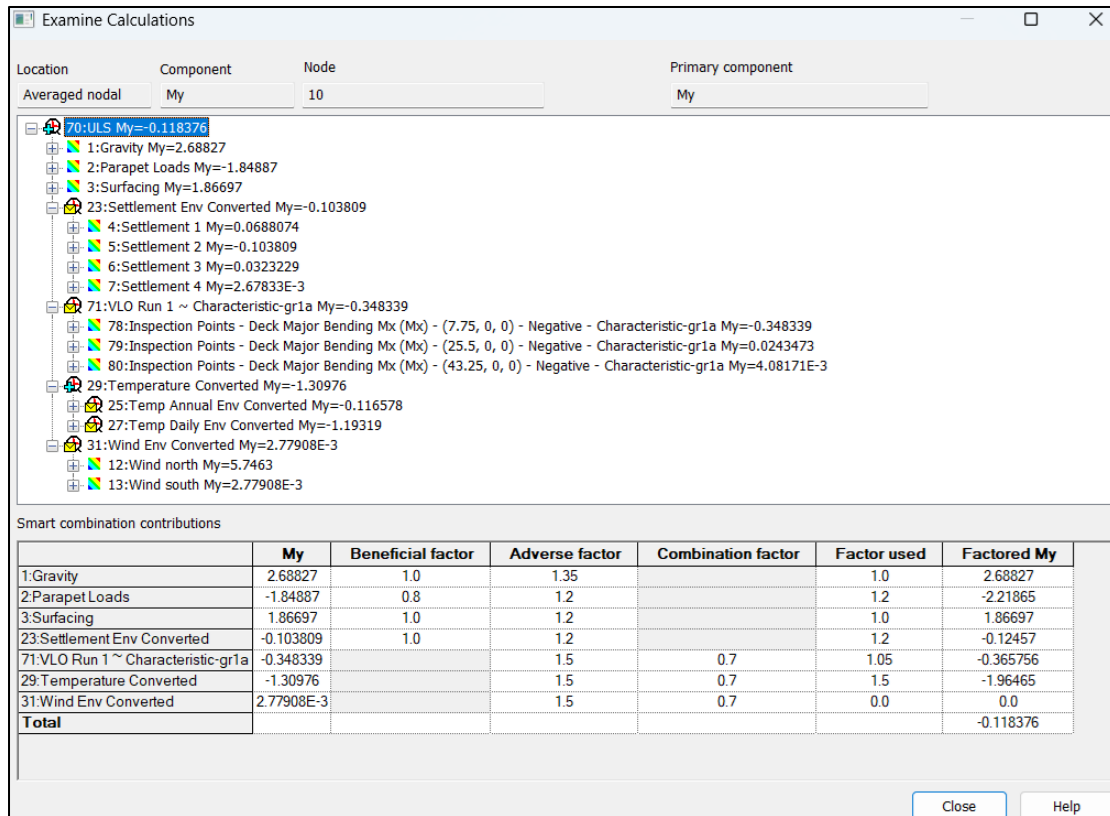


Figure 6 – Smart Combination – Minimum result.

5. Summary

Smart Combinations allow results from individual loadcases – if needed from multiple analyses – as well as from *Basic Combinations*, other *Smart Combinations*, or *Envelopes*, to be multiplied by a beneficial or adverse factor and then combined.

Envelopes allow the maximum and minimum results from individual loadcases – if needed from multiple analyses – as well as from *Basic Combinations*, *Smart Combinations*, or other *Envelopes*, to be determined.

Results retrieved using the *Print Results Wizard* facility can be inspected by right-clicking on values of interest and selecting the *Examine Calculations* option.

If you have any doubts or require specific advice for your type of analysis, please contact the LUSAS Technical Support team at support@lusas.com.