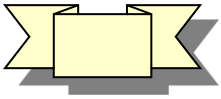
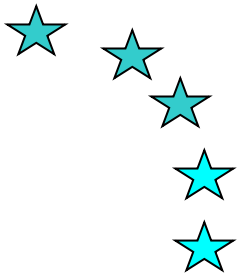


GRISPE



Guidelines and **R**ecommendations for **I**ntegrating **S**pecific **P**rofiled steel sheets in the **E**urocodes (**GRISPE**)

WP4 Doc 4 Version 01

Test analysis and interpretation

Working Package 4

Deliverable D 4.4

Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)

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Summary

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1. Aim and scope of the tests

Plank profiles, mainly for aesthetics considerations, are becoming a common cladding profile. Despite this observation, [1] doesn't offer any way to design by calculation these planks. In this document, we will determine the resistance of such profiles based on results of tests operated following Annex A of [1]. To avoid local unfavourable behaviour, and to the most realistic results, bending tests were performed in a vacuum chamber.

There are many plank profiles on the market with many shapes of joints. This joint is a critical point because the dislocation of this joint can be, under suction loads, a failure mode.

a b

Figure 1 Examples of joints shape (a: clipped joint; b: chevron shaped joint)

Therefore, the horizontal displacements of the joints were measured on suction tests, to evaluate the influence of the shape of the joint on the dislocation design criteria.

Two different profiles, CLADEO 300 (from BACACIER) and ZEPHIR 300 (from JORIS IDE) were tested, both in nominal thicknesses 0.75 and 1 mm. These were tested in the following configurations:

- Single span
- Double span
- End support

The values exposed thereafter are extracted from [2].

2. Resistance values

2.1. Single span in pressure tests

The test setup was as following:

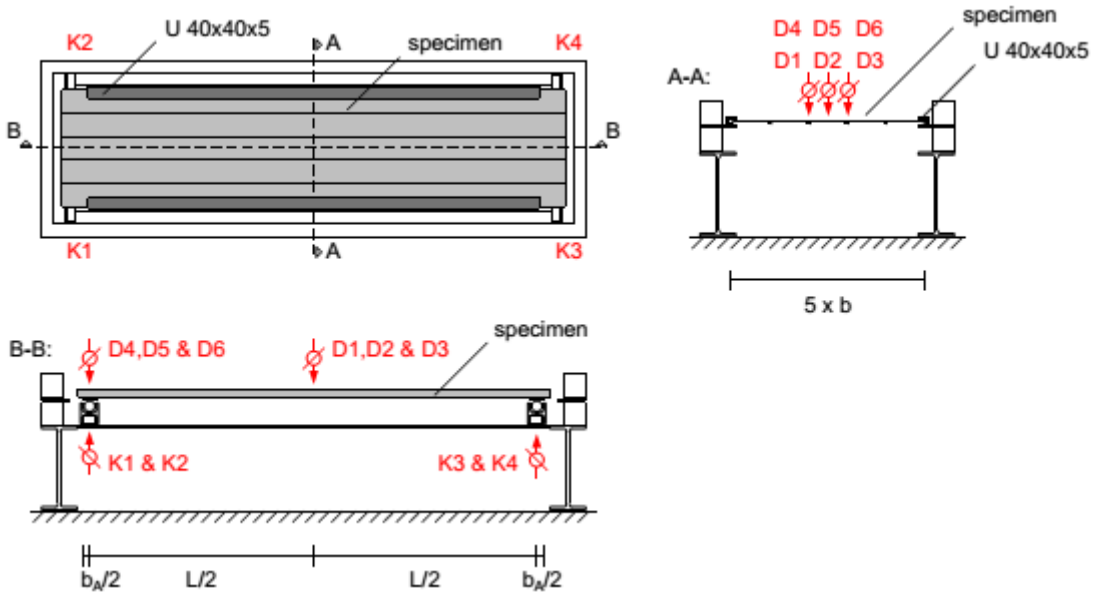

Figure 2 Test setup (single span pressure tests)

The failure occurred by local buckling, in mid span, of the compressed flange for every test.

Figure 3 Failure by local buckling of the compressed flange (left: CLADEO 300 t=0.75mm ; right ZEPHIR 300 with reinforcement t = 1 mm)

Test index	**Nominal thickness** mm	**Nom. yield strength** MPa	**Span** mm	**Failure mode**	t_{obs} mm	$f_{yb,obs}$ MPa	**α**	**β**	μ_R	F_{max} kN	q_{max} kN/m²	M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
SSP-C-075-1	0,75	320	1500	Local buckling	0,64	353	0,5	1,0	0,896	7,31	3,25	0,91	0,93	1,03
SSP-C-075-2			1500		0,64	359	0,5	1,0	0,904	7,65	3,40	0,96		
SSP-C-075-3			1500		0,64	362	0,5	1,0	0,908	7,39	3,28	0,92		
SSP-C-100-1	1,00	320	1500	Local buckling	0,97	352	0,5	1,0	1,017	15,26	6,78	1,91	1,91	1,87
SSP-C-100-2			1500		0,97	349	0,5	1,0	1,013	15,42	6,85	1,93		
SSP-C-100-3			1500		0,97	366	0,5	1,0	1,037	15,13	6,72	1,89		

Table 1 CLADEO 300 performances for single span pressure tests

Test index	**Nominal thickness** mm	**Nom. yield strength** MPa	**Span** mm	**Failure mode**	t_{obs} mm	$f_{yb,obs}$ MPa	**α**	**β**	μ_R	F_{max} kN	q_{max} kN/m²	M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
SSP-Z-075-1	0,75	320	1500	Local buckling	0,71	391	0,5	1,0	1,05	10,04	4,46	1,26	1,30	1,24
SSP-Z-075-2			1500		0,71	392	0,5	1,0	1,05	10,60	4,71	1,33		
SSP-Z-075-3			1500		0,71	394	0,5	1,0	1,05	10,61	4,72	1,33		
SSP-Z-100-1	1,00	320	1500	Local buckling	0,94	374	0,5	1,0	1,02	15,11	6,72	1,89	1,92	1,87
SSP-Z-100-2			1500		0,94	390	0,5	1,0	1,04	15,42	6,85	1,93		
SSP-Z-100-3			1500		0,94	385	0,5	1,0	1,03	15,53	6,90	1,94		

Table 2 ZEPHIR 300 without reinforcement performances for single span pressure tests

Test index	**Nominal thickness** mm	**Nom. yield strength** MPa	**Span** mm	**Failure mode**	t_{obs} mm	$f_{yb,obs}$ MPa	**α**	**β**	μ_R	F_{max} kN	q_{max} kN/m²	M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
SSP-ZR-075-1	0,75	320	1500	Local buckling	0,71	386	0,5	1,0	1,04	9,72	4,32	1,22	1,22	1,17
SSP-ZR-075-2			1500		0,71	392	0,5	1,0	1,05	9,77	4,34	1,22		
SSP-ZR-075-3			1500		0,71	393	0,5	1,0	1,05	9,86	4,38	1,23		
SSP-ZR-100-1	1,00	320	1500	Local buckling	0,94	380	0,5	1,0	1,02	16,14	7,17	2,02	2,02	1,97
SSP-ZR-100-2			1500		0,94	374	0,5	1,0	1,02	16,03	7,12	2,00		
SSP-ZR-100-3			1500		0,94	388	0,5	1,0	1,04	16,35	7,27	2,04		

Table 3 ZEPHIR 300 with reinforcement performances for single span pressure tests

2.2. Single span in suction tests

The test setup was as following:

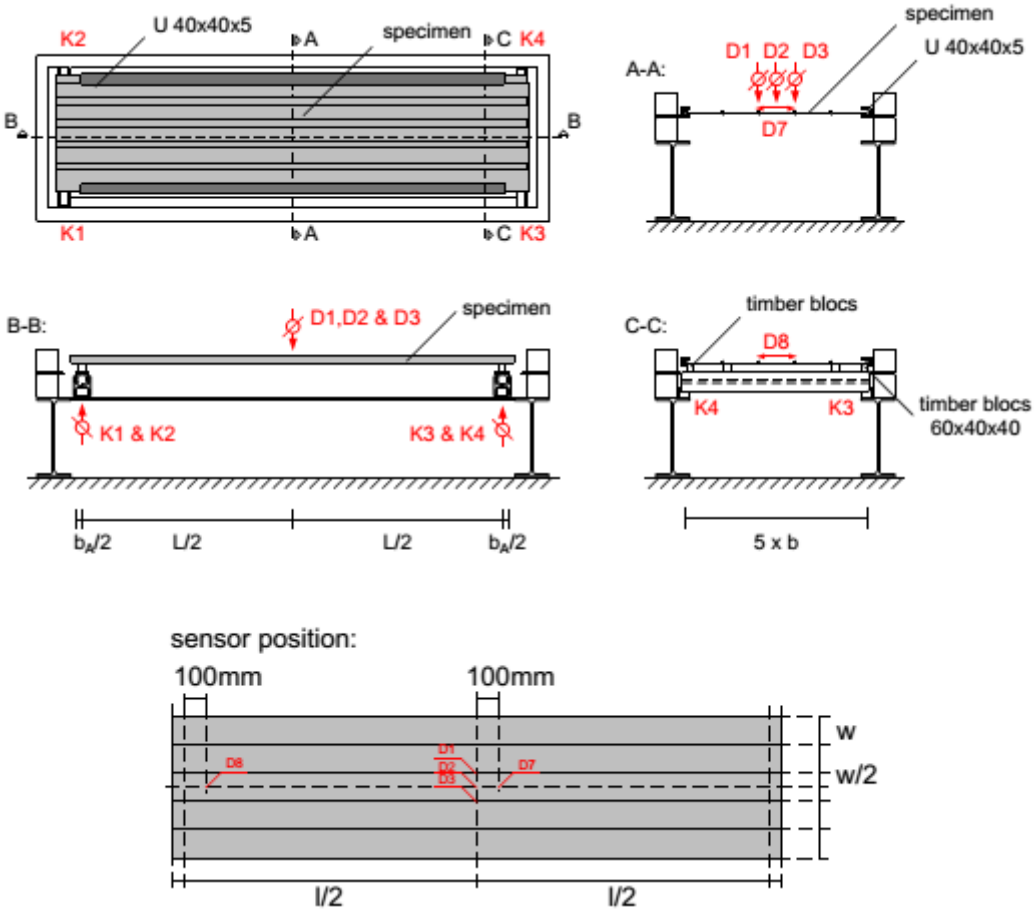

Figure 4 Test setup (single span suction tests)

Horizontal displacement was measured but will not further be interpreted because the values were not probing. This could be because of the position of the horizontal displacement sensor on the plastic foil. Indeed, when the plastic foil moves, the bases follows the deformation of this foil.

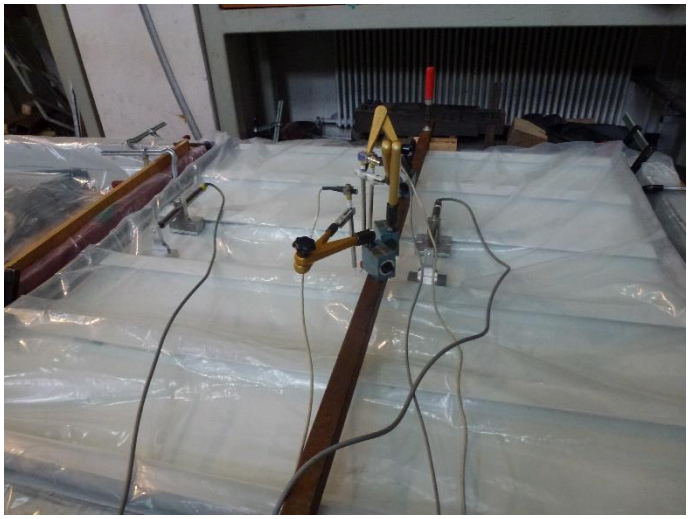

Figure 5 Test setup with horizontal displacement sensors

For most of the tests, failure occurred by local buckling of the compressed flanges.

Figure 6 Failure by local buckling of the compressed flange (left: CLADEO 300 t=1.00mm ; right ZEPHIR 300 without reinforcement t = 0.75 mm)

Failure by dislocation occurred for 2 tests.

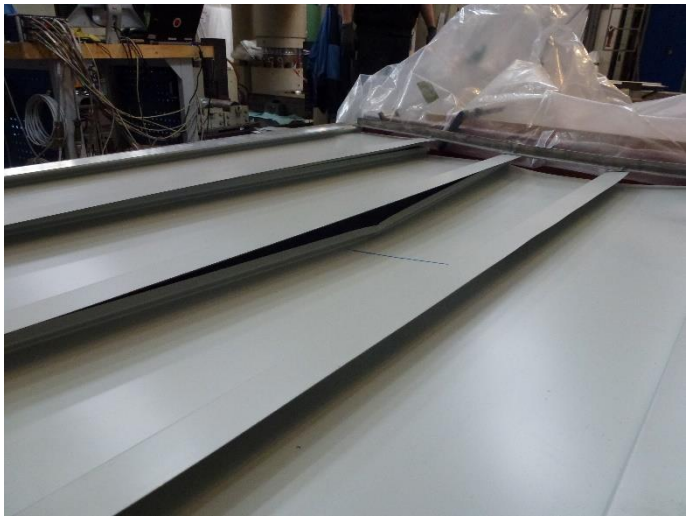

Figure 7 Failure by dislocation (ZEPHIR 300 without reinforcement t=1.00mm)

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	F_{max} kN	q_{max} kN/m²	M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
SSN-C-075-1	0,75	320	1500	Dislocation	–	–	–	–	–	11,18	4,97	1,40	–	–
SSN-C-100-1	1,00	320	1500	Local buckling	0,97	353	0,5	1,0	1,019	17,25	7,67	2,16	2,00	1,96
SSN-C-100-2			1500		0,97	357	0,5	1,0	1,025	15,09	6,71	1,89		
SSN-C-100-3			1500		0,97	354	0,5	1,0	1,020	15,60	6,93	1,95		

Table 4 CLADEO 300 performances for single span suction tests

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	F_{max} kN	q_{max} kN/m²	M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
SSN-Z-075-1	0,75	320	1500	Local buckling	0,72	389	0,5	1,0	1,06	8,49	3,77	1,06	1,22	1,15
SSN-Z-075-2			1500		0,72	387	0,5	1,0	1,06	10,23	4,55	1,28		
SSN-Z-075-3			1500		0,71	391	0,5	1,0	1,05	10,44	4,64	1,31		
SSN-Z-100-1	1,00	320	1500	Local buckling	0,94	383	0,5	1,0	1,03	16,84	7,48	2,11	2,01	1,90
SSN-Z-100-2			1500	Dislocation	0,94	383	1,0	1,0	1,13	15,47	6,88	1,93		
SSN-Z-100-3			1500	Local buckling	0,94	384	0,5	1,0	1,03	15,93	7,08	1,99		

Table 5 ZEPHIR 300 without reinforcement performances for single span suction tests

Test index	**Nominal thickness** mm	**Nom. yield strength** MPa	**Span** mm	**Failure mode**	t_{obs} mm	$f_{yb,obs}$ MPa	**α**	**β**	μ_R	F_{max} kN	q_{max} kN/m²	M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
SSN-ZR-075-1	0,75	320	1500	Local buckling	0,70	394	0,5	1,0	1,04	8,22	3,65	1,03	1,08	1,04
SSN-ZR-075-2			1500		0,71	391	0,5	1,0	1,05	8,69	3,86	1,09		
SSN-ZR-075-3			1500		0,71	389	0,5	1,0	1,04	9,08	4,04	1,14		
SSN-ZR-100-1	1,00	320	1500	Local buckling	0,93	377	0,5	1,0	1,01	16,13	7,17	2,02	1,90	1,87
SSN-ZR-100-2			1500		0,93	384	0,5	1,0	1,02	14,30	6,36	1,79		
SSN-ZR-100-3			1500		0,93	383	0,5	1,0	1,02	15,11	6,72	1,89		

Table 6 ZEPHIR 300 with reinforcement performances for single span suction tests

2.3. Double span in pressure tests

The test setup was as following:

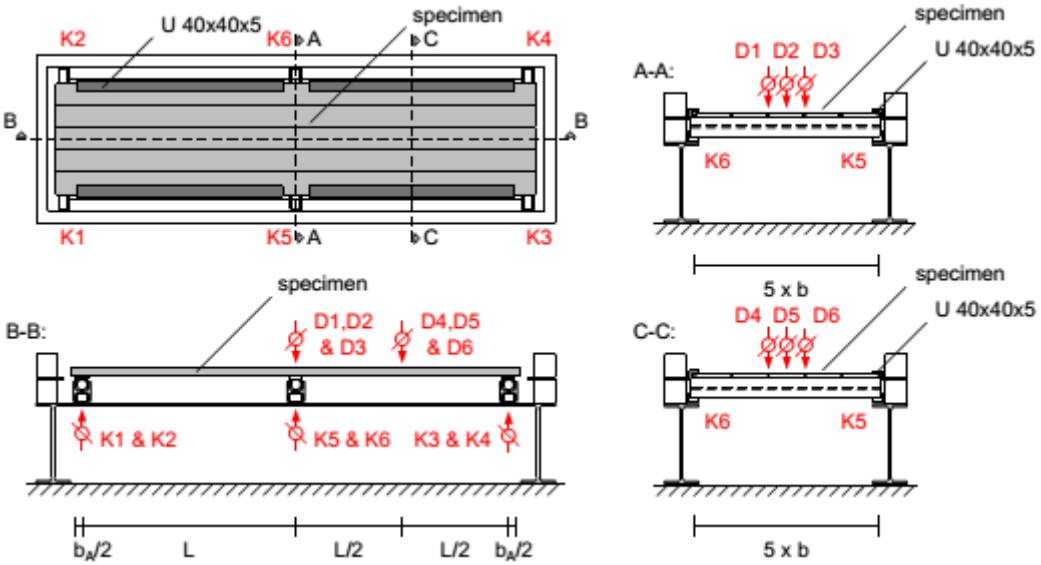

Figure 8 Test setup (double span pressure tests)

For the small span (1 m), no failure occurred.

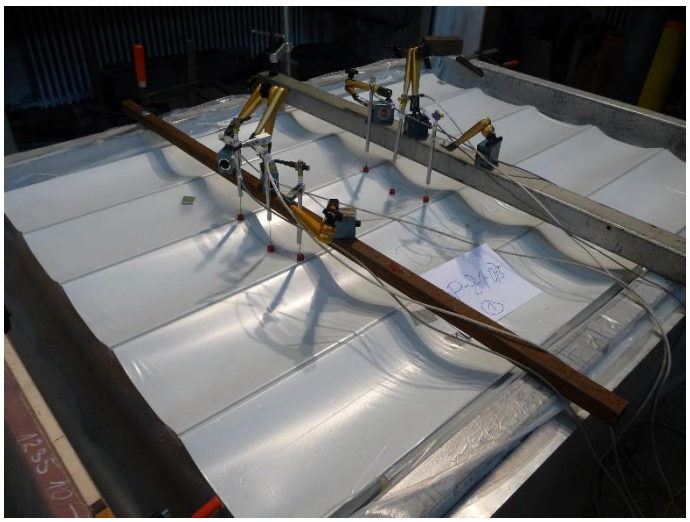

Figure 9 Maximal deflection without failure (ZEPHIR 300 without reinforcement t = 1.00m)

Failure, when it occur, appears by local buckling of the compressed flange, in mid span.

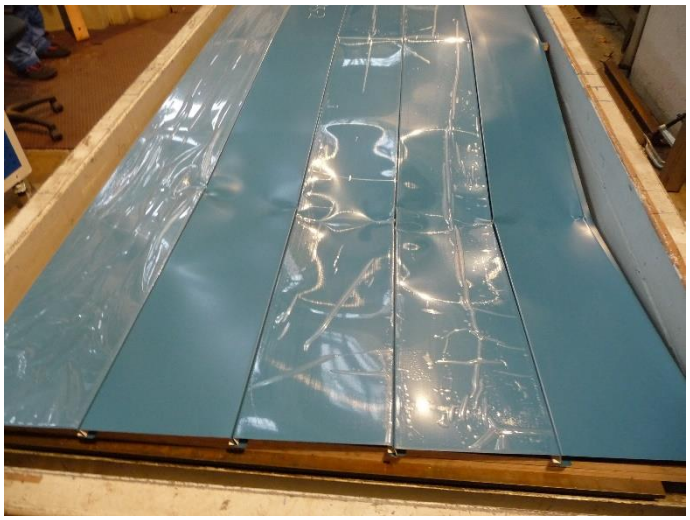

Figure 10 Failure by local buckling (CLADEO 300 t = 0.75 mm)

Analysing the results, we can see that there is a small difference between the uniform loads applied in the two spans. Indeed, the reactions on the two extreme supports are slightly different.

Based on the reactions values, we can see that the profile is behaving as if the intermediate support was a hinge. Therefore, we only evaluate the moment resistance in span.

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	q values kN/m²		Reaction kN/m			Span moment kN·m/m		M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
										AB span	BC span	R_A	R_B	R_C	AB span	BC span			
DSP-C-1-075-1	0,75	320	1000	No failure	–	–	–	–	–	10,781	11,112	5,320	11,087	5,486	1,312	1,354	1,35	–	–
DSP-C-2-075-1			2000	Local buckling	0,64	345	0,5	1,0	0,886	2,148	2,124	1,976	4,615	1,952	0,902	0,890	0,90	1,02	1,15
DSP-C-2-075-2			2000		0,64	337	0,5	1,0	0,876	2,133	2,088	1,990	4,506	1,945	0,923	0,901	0,92		
DSP-C-2-075-3			2000		0,63	337	0,5	1,0	0,862	2,118	2,081	1,962	4,509	1,925	0,904	0,885	0,90		
DSP-C-3-075-1			3000		0,64	336	0,5	1,0	0,874	1,079	1,088	1,537	3,415	1,549	1,091	1,100	1,10		
DSP-C-3-075-2			3000		0,64	365	0,5	1,0	0,911	1,128	1,098	1,607	3,508	1,563	1,142	1,109	1,14		
DSP-C-3-075-3			3000		0,64	367	0,5	1,0	0,914	1,128	1,109	1,621	3,496	1,594	1,163	1,142	1,16		
DSP-C-2-100-1	1,00	320	2000	Local buckling	0,97	351	0,5	1,0	1,016	4,936	4,952	4,722	10,315	4,739	2,254	2,262	2,26	2,06	2,02
DSP-C-2-100-2			2000		0,97	351	0,5	1,0	1,016	4,507	4,420	4,024	9,893	3,937	1,771	1,727	1,77		
DSP-C-2-100-3			2000		0,97	350	0,5	1,0	1,014	4,405	4,268	3,983	9,515	3,847	1,781	1,713	1,78		
DSP-C-3-100-1			3000		0,97	351	0,5	1,0	1,016	2,239	2,218	3,170	7,061	3,138	2,236	2,212	2,24		
DSP-C-3-100-2			3000		0,97	354	0,5	1,0	1,020	2,239	2,222	3,147	7,113	3,122	2,202	2,183	2,20		
DSP-C-3-100-3			3000		0,97	347	0,5	1,0	1,010	2,303	2,291	3,117	7,566	3,099	2,085	2,071	2,08		

Table 7 CLADEO 300 performances for double span pressure tests

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	q values kN/m²		Reaction kN/m			Span moment kN·m/m		M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
										AB span	BC span	R_A	R_B	R_C	AB span	BC span			
DSP-Z-1-075-1	0,75	320	1000	No failure	–	–	–	–	–	10,779	11,109	5,319	11,084	5,485	1,312	1,354	1,35	–	–
DSP-Z-2-075-1			2000	Local buckling	0,71	402	0,5	1,0	1,061	3,114	3,065	2,884	6,639	2,835	1,327	1,302	1,33	1,43	1,36
DSP-Z-2-075-2			2000		0,71	398	0,5	1,0	1,056	3,012	3,019	2,769	6,517	2,776	1,263	1,267	1,27		
DSP-Z-2-075-3			2000		0,70	396	0,5	1,0	1,038	3,140	3,172	2,888	6,816	2,919	1,318	1,333	1,33		
DSP-Z-3-075-1			3000		0,71	400	0,5	1,0	1,058	1,469	1,449	2,149	4,488	2,119	1,570	1,548	1,57		
DSP-Z-3-075-2			3000		0,71	397	0,5	1,0	1,054	1,450	1,441	2,131	4,426	2,117	1,565	1,554	1,57		
DSP-Z-3-075-3			3000		0,71	394	0,5	1,0	1,050	1,382	1,404	2,029	4,267	2,061	1,489	1,513	1,51		
DSP-Z-2-100-1	1,00	320	2000	Local buckling	0,93	376	0,5	1,0	1,008	4,455	4,367	4,260	9,211	4,172	2,033	1,989	2,03	2,26	2,22
DSP-Z-2-100-2			2000		0,93	378	0,5	1,0	1,011	4,569	4,343	4,407	9,236	4,181	2,122	2,010	2,12		
DSP-Z-2-100-3			2000		0,94	379	0,5	1,0	1,023	4,491	4,253	4,328	9,070	4,090	2,083	1,963	2,08		
DSP-Z-3-100-1			3000		0,94	376	0,5	1,0	1,019	2,353	2,327	3,368	7,341	3,329	2,405	2,376	2,41		
DSP-Z-3-100-2			3000		0,94	382	0,5	1,0	1,027	2,419	2,348	3,464	7,482	3,357	2,474	2,394	2,47		
DSP-Z-3-100-3			3000		0,93	380	0,5	1,0	1,013	2,407	2,347	3,425	7,503	3,336	2,430	2,362	2,43		

Table 8 ZEPHIR 300 without reinforcement performances for double span pressure tests

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	q values kN/m²		Reaction kN/m			Span moment kN·m/m		M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
										AB span	BC span	R_A	R_B	R_C	AB span	BC span			
DSP-ZR-1-075-1	0,75	320	1000	No failure	–	–	–	–	–	10,912	11,014	5,739	10,398	5,790	1,505	1,518	1,52	–	–
DSP-ZR-2-075-1			2000	Local buckling	0,72	394	0,5	1,0	1,065	3,063	2,936	2,826	6,473	2,699	1,295	1,231	1,29	1,45	1,37
DSP-ZR-2-075-2			2000		0,71	399	0,5	1,0	1,057	2,977	2,931	2,741	6,379	2,696	1,253	1,230	1,25		
DSP-ZR-2-075-3			2000		0,71	401	0,5	1,0	1,060	3,212	3,096	2,961	6,810	2,845	1,355	1,297	1,36		
DSP-ZR-3-075-1			3000		0,71	403	0,5	1,0	1,062	1,447	1,443	2,135	4,405	2,130	1,575	1,571	1,58		
DSP-ZR-3-075-2			3000		0,71	398	0,5	1,0	1,056	1,505	1,491	2,203	4,600	2,183	1,612	1,597	1,61		
DSP-ZR-3-075-3			3000		0,71	402	0,5	1,0	1,061	1,512	1,514	2,197	4,683	2,200	1,595	1,597	1,60		
DSP-ZR-2-100-1	1,00	320	2000	Local buckling	0,94	353	0,5	1,0	0,987	4,485	4,185	4,206	9,228	3,906	1,964	1,813	1,96	2,13	2,14
DSP-ZR-2-100-2			2000		0,95	362	0,5	1,0	1,010	4,410	4,123	4,199	8,955	3,912	1,994	1,851	1,99		
DSP-ZR-2-100-3			2000		0,94	356	0,5	1,0	0,991	4,334	4,202	4,128	8,948	3,997	1,961	1,895	1,96		
DSP-ZR-3-100-1			3000		0,95	348	0,5	1,0	0,991	2,223	2,198	3,170	6,963	3,132	2,253	2,225	2,25		
DSP-ZR-3-100-2			3000		0,94	354	0,5	1,0	0,989	2,226	2,194	3,198	6,910	3,151	2,293	2,258	2,29		
DSP-ZR-3-100-3			3000		0,94	355	0,5	1,0	0,990	2,226	2,177	3,195	6,895	3,121	2,287	2,232	2,29		

Table 9 ZEPHIR 300 with reinforcement performances for double span pressure tests

2.4. Double span in suction tests

The test setup was as following:

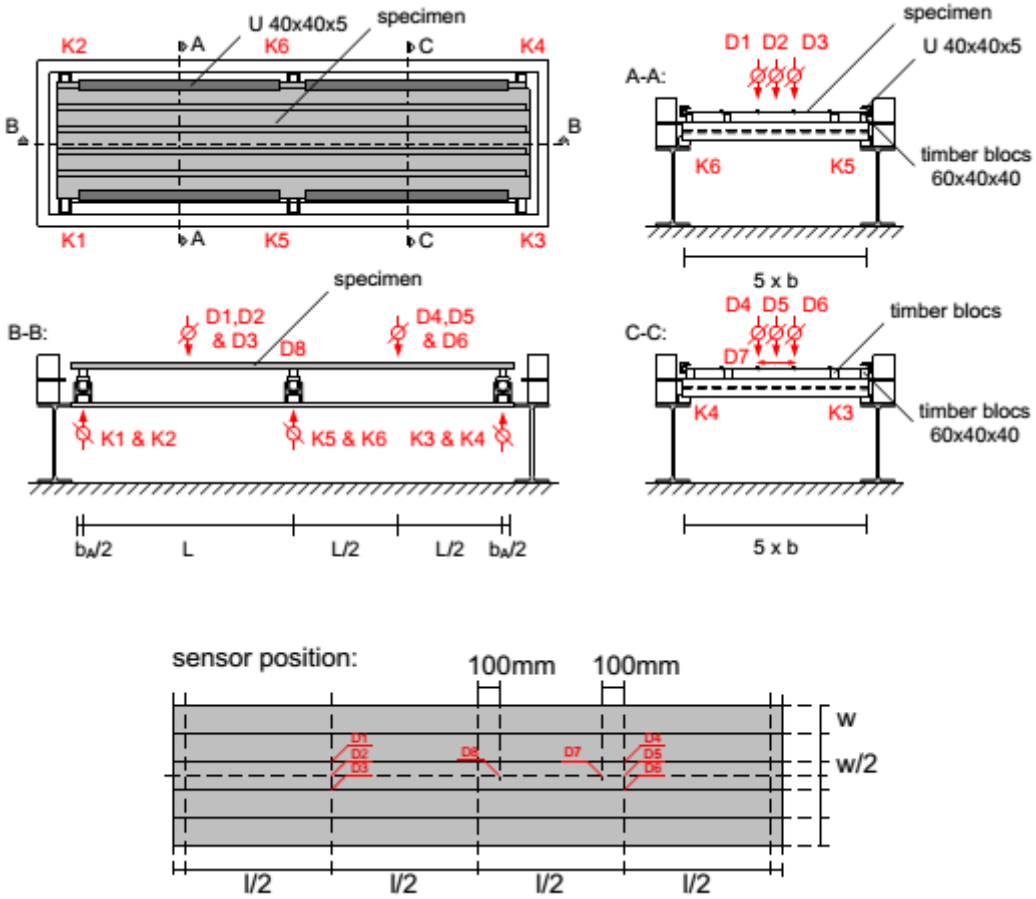

Figure 11 Test setup (double span suction tests)

During these tests, two failure modes occurred. For the small spans (1 and 2 m), failure, when it occurred, was provoked by local buckling of the compressed flanges in mid span.

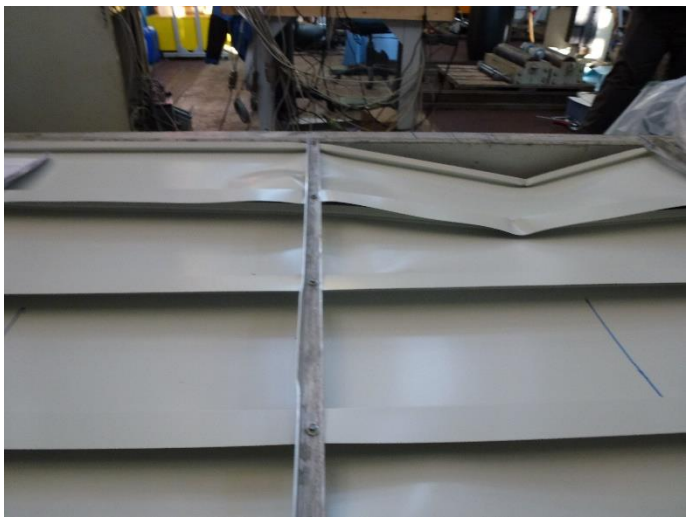

Figure 12 Failure by local buckling (ZEPHIR 300 without reinforcement t = 0.75 mm)

For greater spans (3 m), failure mostly occurred by local buckling, as previously. But, regularly, failure also happened by dislocation of the joints. This is a typical and particular failure mode for these profiles.

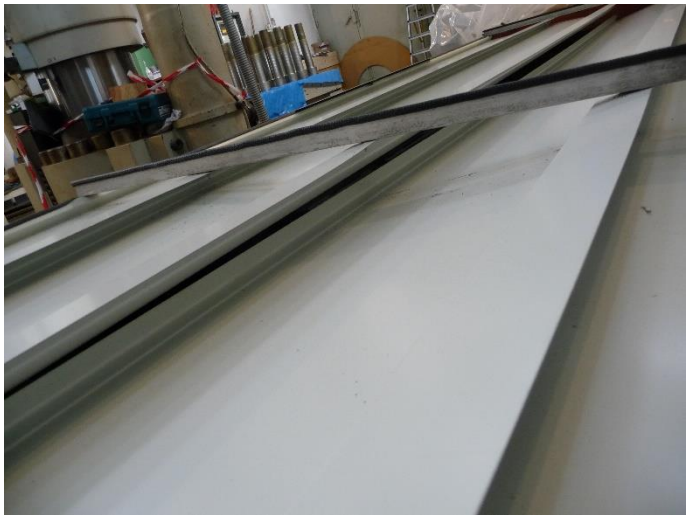

Figure 13 Failure by dislocation of the joint (ZEPHIR 300 without reinforcement t = 0.75mm)

Like for pressure tests, the moment resistance of the profiles, regarding local buckling failure, is only evaluated in mid span because intermediate support, based on the reaction values, is acting like a hinge.

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	q values kN/m²		Reaction kN/m			Span moment kN·m/m		M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
										AB span	BC span	R_A	R_B	R_C	AB span	BC span			
DSN-C-1-075-1	0,75	320	1000	Local buckling	0,64	366	0,5	1,0	0,913	9,249	9,653	4,724	9,251	4,927	1,206	1,257	1,26	0,84	1,22
DSN-C-1-075-2			1000		0,64	352	0,5	1,0	0,895	9,214	9,326	4,593	9,298	4,649	1,145	1,159	1,16		
DSN-C-1-075-3			1000		0,65	358	0,5	1,0	0,917	10,824	10,964	5,373	10,971	5,443	1,334	1,351	1,35		
DSN-C-2-075-1			2000		0,64	358	0,5	1,0	0,903	2,343	2,284	2,073	5,166	2,015	0,902	0,873	0,90		
DSN-C-2-075-2			2000		0,64	336	0,5	1,0	0,874	2,377	2,314	2,098	5,249	2,035	0,910	0,878	0,91		
DSN-C-2-075-3			2000		0,63	355	0,5	1,0	0,885	2,556	2,532	2,280	5,640	2,257	1,002	0,990	1,00		
DSN-C-3-075-1			3000	Dislocation	0,64	368	1,0	1,0	0,981	0,836	0,842	1,067	2,889	1,076	0,661	0,668	0,67	–	–
DSN-C-3-075-2			3000		0,64	367	1,0	1,0	0,979	0,996	0,986	1,291	3,378	1,276	0,817	0,805	0,82		
DSN-C-3-075-3			3000		0,64	360	1,0	1,0	0,960	0,962	0,955	1,235	3,290	1,225	0,771	0,763	0,77		
DSN-C-2-100-1	1,00	320	2000	Local buckling	0,97	351	0,5	1,0	1,016	4,850	4,760	4,186	10,938	4,096	1,761	1,716	1,76	1,77	1,74
DSN-C-2-100-2			2000		0,97	351	0,5	1,0	1,016	4,544	4,510	3,785	10,571	3,751	1,513	1,496	1,51		
DSN-C-2-100-3			2000		0,97	350	0,5	1,0	1,014	4,801	4,807	4,008	11,194	4,014	1,608	1,611	1,61		
DSN-C-3-100-1			3000		0,97	351	0,5	1,0	1,016	2,512	2,526	3,187	8,720	3,208	1,954	1,970	1,97		
DSN-C-3-100-2			3000		0,97	354	0,5	1,0	1,020	2,566	2,539	3,184	8,987	3,144	1,890	1,859	1,89		
DSN-C-3-100-3			3000		0,97	347	0,5	1,0	1,010	2,573	2,559	3,175	9,067	3,153	1,868	1,852	1,87		

Table 10 CLADEO 300 performances for double span suction tests

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	q values kN/m²		Reaction kN/m			Span moment kN·m/m		M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
										AB span	BC span	R_A	R_B	R_C	AB span	BC span			
DSN-Z-1-075-1	0,75	320	1000	Local buckling	0,71	390	0,5	1,0	1,045	11,132	11,301	5,894	10,561	5,978	1,555	1,577	1,58	0,69	1,12
DSN-Z-1-075-2			1000		0,71	387	0,5	1,0	1,041	10,749	10,420	5,294	10,745	5,130	1,304	1,263	1,30		
DSN-Z-1-075-3			1000		0,71	396	0,5	1,0	1,053	9,020	8,864	4,653	8,656	4,575	1,199	1,180	1,20		
DSN-Z-2-075-1			2000		0,71	365	0,5	1,0	1,011	2,966	2,923	2,682	6,456	2,640	1,199	1,178	1,20		
DSN-Z-2-075-2			2000		0,72	393	0,5	1,0	1,064	2,601	2,532	2,240	5,855	2,171	0,939	0,905	0,94		
DSN-Z-2-075-3			2000		0,71	394	0,5	1,0	1,050	1,933	1,833	1,731	4,170	1,631	0,764	0,715	0,76		
DSN-Z-3-075-1			3000	Dislocation	0,70	396	1,0	1,0	1,155	0,620	0,629	0,783	2,169	0,797	0,476	0,487	0,49	–	–
DSN-Z-3-075-2			3000		0,71	396	1,0	1,0	1,172	0,538	0,523	0,690	1,825	0,668	0,430	0,413	0,43		
DSN-Z-3-075-3			3000		0,71	395	1,0	1,0	1,169	0,439	0,439	0,556	1,520	0,557	0,340	0,341	0,34		
DSN-Z-1-100-1	1,00	320	1000	No failure	–	–	–	–	–	10,170	10,423	5,582	9,303	5,708	1,520	1,551	1,55	–	–
DSN-Z-2-100-1			2000	Local buckling	0,93	384	0,5	1,0	1,019	3,200	3,119	2,870	6,980	2,789	1,270	1,229	1,27	1,32	1,30
DSN-Z-2-100-2			2000		0,93	375	0,5	1,0	1,007	3,525	3,497	3,055	7,960	3,027	1,293	1,279	1,29		
DSN-Z-2-100-3			2000		0,93	382	0,5	1,0	1,016	3,375	3,381	3,074	7,356	3,080	1,387	1,390	1,39		
DSN-Z-3-100-1			3000	Dislocation	0,94	375	1,0	1,0	1,102	0,994	0,988	1,266	3,424	1,258	0,781	0,774	0,78	–	–
DSN-Z-3-100-2			3000		0,94	375	1,0	1,0	1,102	1,020	1,016	1,305	3,505	1,299	0,810	0,805	0,81		
DSN-Z-3-100-3			3000		0,93	378	1,0	1,0	1,099	1,154	1,124	1,489	3,902	1,444	0,935	0,901	0,94		

Table 11 ZEPHIR 300 without reinforcement performances for double span suction tests

Test index	Nominal thickness mm	Nom. yield strength MPa	Span mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	q values kN/m²		Reaction kN/m			Span moment kN·m/m		M_{max} kN·m/m	M_{mean} kN·m/m	M_{Rd} kN·m/m
										AB span	BC span	R_A	R_B	R_C	AB span	BC span			
DSN-ZR-1-075-1	0,75	320	1000	Local buckling	0,71	405	0,5	1,0	1,065	9,434	9,331	5,156	8,506	5,104	1,398	1,386	1,40	1,09	1,03
DSN-ZR-1-075-2			1000		0,71	395	0,5	1,0	1,052	8,696	8,880	4,639	8,205	4,731	1,233	1,256	1,26		
DSN-ZR-1-075-3			1000		0,72	394	0,5	1,0	1,065	10,480	10,422	5,564	9,803	5,535	1,472	1,465	1,47		
DSN-ZR-2-075-1			2000		0,71	400	0,5	1,0	1,058	2,215	2,118	1,999	4,765	1,901	0,891	0,842	0,89		
DSN-ZR-2-075-2			2000		0,71	397	0,5	1,0	1,054	2,273	2,207	1,982	5,061	1,916	0,846	0,813	0,85		
DSN-ZR-2-075-3			2000		0,71	395	0,5	1,0	1,052	1,971	1,909	1,778	4,266	1,716	0,792	0,762	0,79		
DSN-ZR-3-075-1			3000		0,71	396	0,5	1,0	1,053	1,357	1,313	1,762	4,555	1,696	1,115	1,066	1,12		
DSN-ZR-3-075-2			3000		0,72	397	0,5	1,0	1,069	1,098	1,083	1,435	3,696	1,412	0,917	0,900	0,92		
DSN-ZR-3-075-3			3000		0,72	388	0,5	1,0	1,057	1,343	1,337	1,730	4,590	1,722	1,084	1,078	1,08		
DSN-ZR-2-100-1	1,00	320	2000	Local buckling	0,95	358	0,5	1,0	1,005	4,397	4,367	3,765	10,027	3,735	1,567	1,552	1,57	1,62	1,74
DSN-ZR-2-100-2			2000		0,95	362	0,5	1,0	1,010	4,589	4,464	3,854	10,523	3,730	1,560	1,498	1,56		
DSN-ZR-2-100-3			2000		0,94	364	0,5	1,0	1,003	4,033	3,909	3,594	8,822	3,469	1,577	1,515	1,58		
DSN-ZR-3-100-1			3000		0,94	354	0,5	1,0	0,989	2,257	2,278	2,783	8,007	2,815	1,636	1,659	1,66		
DSN-ZR-3-100-2			3000		0,95	361	0,5	1,0	1,009	2,232	2,209	2,751	7,857	2,717	1,616	1,590	1,62		
DSN-ZR-3-100-3			3000		0,65	359	0,5	1,0	0,688	2,239	2,244	2,821	7,798	2,828	1,713	1,718	1,72		

Table 12 ZEPHIR 300 with reinforcement performances for double span suction tests

2.5. End support tests

The test setup was as following:

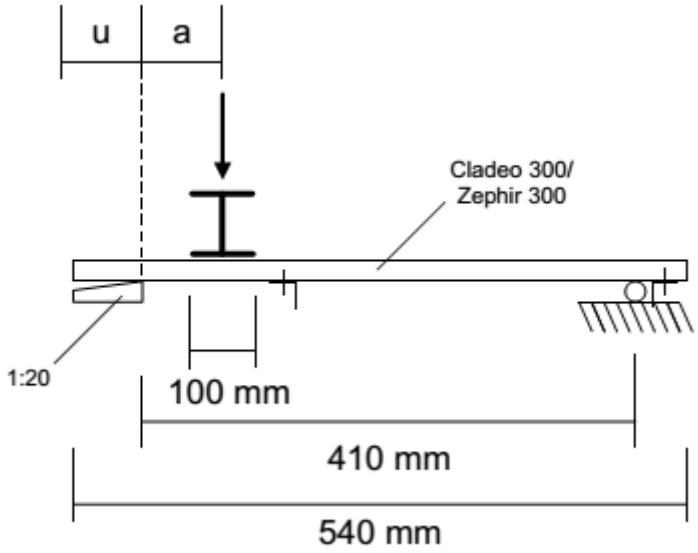

Figure 14 Test setup

Failure occur by web crippling on the sharp edge or by local buckling under load application.

Figure 15 Failure by web crippling (end support tests)

Figure 16 Failure by local buckling (end support tests)

Test index	**Nominal thickness** mm	**Nom. yield strength** MPa	**u length** mm	**Failure mode**	t_{obs} mm	$f_{yb,obs}$ MPa	**α**	**β**	μ_R	F_{max} kN	F_{mean} kN/m	F_{Rd} kN/m
ES-C-075-40-1	0,75	320	40	Shear effect	0,64	360	1,0	1,0	0,960	8,82	11,24	11,95
ES-C-075-40-2					0,64	363	1,0	1,0	0,968	10,32		
ES-C-075-40-3					0,64	368	1,0	1,0	0,981	10,23		
ES-C-075-80-1			80	Flexion	0,64	359	0,5	1,0	0,904	10,47		
ES-C-075-80-2					0,64	363	0,5	1,0	0,909	10,33		
ES-C-075-80-3					0,65	367	0,5	1,0	0,928	10,51		
ES-C-100-40-1	1,00	320	40	Flexion	0,97	344	0,5	1,0	1,006	21,45	23,24	22,90
ES-C-100-40-2					0,97	353	0,5	1,0	1,0188	21,35		
ES-C-100-40-3					0,97	353	0,5	1,0	1,0188	20,63		
ES-C-100-80-1			80		0,97	345	0,5	1,0	1,0072	20,53		
ES-C-100-80-2					0,97	353	0,5	1,0	1,0188	20,98		
ES-C-100-80-3					0,97	353	0,5	1,0	1,0188	20,53		

Table 13 CLADEO 300 performances for end support tests

Test index	Nominal thickness mm	Nom. yield strength MPa	u length mm	Failure mode	t_{obs} mm	$f_{yb,obs}$ MPa	α	β	μ_R	F_{max} kN	F_{mean} kN/m	F_{Rd} kN/m
ES-Z-075-40-1	0,75	320	40	Shear effect	0,71	387	1,0	1,0	1,145	9,72	10,94	9,49
ES-Z-075-40-2					0,71	387	1,0	1,0	1,145	9,78		
ES-Z-075-40-3					0,71	394	1,0	1,0	1,166	10,44		
ES-Z-075-80-1			80		0,71	388	1,0	1,0	1,148	9,67		
ES-Z-075-80-2					0,71	392	1,0	1,0	1,160	9,82		
ES-Z-075-80-3					0,71	389	1,0	1,0	1,151	9,63		
ES-Z-100-40-1	1,00	320	40	Shear effect	0,94	371	1,0	1,0	1,090	16,54	17,85	16,78
ES-Z-100-40-2					0,94	385	1,0	1,0	1,131	16,47		
ES-Z-100-40-3					0,94	379	1,0	1,0	1,113	16,33		
ES-Z-100-80-1			80	Flexion	0,94	370	0,5	1,0	1,011	15,97		
ES-Z-100-80-2					0,93	385	0,5	1,0	1,020	14,98		
ES-Z-100-80-3					0,94	379	0,5	1,0	1,023	16,08		

Table 14 ZEPHIR 300 performances for end support tests

Conclusion

The double span tests, in both pressure and suction, were very relevant because the profiles are behaving as if the intermediate support was acting like a hinge. Thus, we can compare the bending moment performances for single span and double span tests. When we compare these values, we can see that they are in the same range. This means that we will only evaluate the solicitations on plank profiles with an isostatic model.

The comparison of the performances between the profiles ZEPHIR with and without reinforcement (transversal edges) reveals that this reinforcement has no real influence on the bending moment resistance. Based on the previous conclusion, this is understandable, because such an edge can only have a slight influence on the local buckling of the flange in the mid span.

References

[1] CEN, EN 1993–1–3 : Design of steel structures – General rule – Supplementary rules for cold-formed member and sheeting, 2006.

[2] C. FAUTH, GRISPE – WP4: Calculation method for cladding systems – D 4.3 Test report, 2016.