

**Zeitschrift:** IABSE reports = Rapports AIPC = IVBH Berichte  
**Band:** 60 (1990)

**Artikel:** Comparative study of composite slab tests  
**Autor:** O'Leary, David / Moum, Chanta / Brekelmans, Jan  
**DOI:** <https://doi.org/10.5169/seals-46456>

### **Nutzungsbedingungen**

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

### **Conditions d'utilisation**

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

### **Terms of use**

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

**Download PDF:** 01.04.2026

**ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>**

## Comparative Study of Composite Slab Tests

Etude comparative d'essais de dalles mixtes

Vergleichsstudie von Versuchen an Verbundplatten

### David O'LEARY

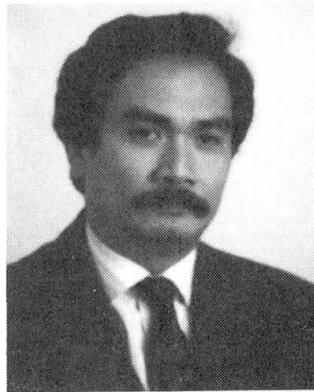
Researcher  
University of Salford  
Salford, UK



D.C. O'Leary, graduated from University College of Swansea in 1959. After research and working on heavy steel design and road and bridge construction, he went to Salford University working on composite construction.

### Chanta MOUM

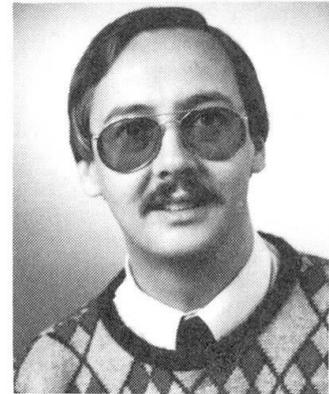
Research engineer  
CTICM  
St. Rémy les Chevreu-  
se, F



Ch. Moum, born in 1949, got his engineering diploma at the Ecole Centrale de Paris in 1974. In 1975 he became a research engineer at the institute CTICM.

### Jan BREKELMANS

Res. Eng.  
TNO-IBBC  
Rijkswijk, NL



J.W.P.M. Brekelmans, born in 1951, was educated at the school for Building Engineering in Heerlen (HTS) and Structural Engineering in Amsterdam (HTI) After he worked for six years in industry he became a research engineer at the institute TNO-IBBC.

### SUMMARY

The results are presented of a joint research programme between France, the Netherlands and the United Kingdom on the testing procedure for composite slabs. The results are statistically evaluated using the techniques derived from Eurocode 3. This comparative study has led to in proposals to Eurocode 4 for the evaluation of test results for composite slabs.

### RÉSUMÉ

Cette étude présente les résultats d'un programme de recherche commun à la France, aux Pays-Bas et au Royaume-Uni relatif à la procédure des essais à appliquer à des dalles mixtes. Ces résultats ont été évalués du point de vue statistique en utilisant les techniques tirées de l'Eurocode 3. Cette étude comparative tend à définir des suggestions pour l'Eurocode 4, en vue d'exploiter les résultats d'essais relatifs à des dalles mixtes.

### ZUSAMMENFASSUNG

Die Resultate eines gemeinsamen Forschungsprogrammes der Länder Frankreich, Niederlande und England betreffend der experimentellen Prüfung von Verbunddecken werden vorgestellt. Die Resultate wurden gemäss Eurocode 3 ausgewertet. Diese Vergleichsstudie hat zu Vorschlägen für Eurocode 4 geführt betreffend der Auswertung von Versuchen an Verbunddecken.



## 1. FOREWORD

This paper presents the results of a joint research programme between France, the Netherlands and the United Kingdom which comprised a cross-testing of composite slabs using profiled steel sheeting from each country carried out according to National procedures.

The study has been performed by:

- CTICM (F);
- TNO Institute for Building Materials and Structures (in ass. with CS/CUR, NL);
- Department of Civil Engineering, Salford University (in ass. with BCSA, UK).

The object of the collaboration (carried out with the financial support of EEC commission DG XIII-SPRINT) was to examine the differences between National testing techniques and interpretations of results and to use the study as a basis for proposals to Eurocode 4 for the testing of composite slabs.

Therefore the work concentrated on:

- the exchange of information on current practice within F, UK and NL;
- testing existing products in different laboratories according to National standards;
- a statistical evaluation of the test results of each product and to make a comparison between the derived semi-experimental design values and live load values from loading codes used in the various countries.

The statistical evaluation of the test results will be discussed in this paper. For the detailed information reference is made to the final report of the SPRINT-project RA31 [1].

## 2. INTRODUCTION

Three types of profiled steel sheeting were used in the comparison study. Each participant selected a profiled steel sheet that was manufactured and already tested in that particular country. The selected steel profiles are:

- COFRADAL 60/0,75 mm (Laminoirs de Strasborg, F);
- PRINS PSV 73/0,75 mm (Prins n.v. Dokkum, NL);
- SUPER HOLORIB 51/0,90 mm (Richard Lees, UK).

In each country a full set of six tests on one type of profile and two check tests on another profile was carried out. Furthermore the test results of the manufacturer and some additional tests carried out in the Netherlands (TNO) were available. The tests for which the results were available are shown in table 1.

country where the tests are performed	SPRINT tests of product			Already available and additional tests of product		
	SUPER HOLORIB	PRINS	COFRADAL	SUPER HOLORIB	PRINS	COFRADAL
NL	6	-	2	6	6	-
F	2	6	-	-	-	6
UK	-	2	6	10	-	-

Table 1 Test details.

The tests were carried out according to the National standards or the current practice in the country where the tests are performed. These regulations are the BS 5950: part 4 1982 (UK), the draft RSBV 1984 (NL) and the Procedure d'Avis Technique (F). The differences in testing procedures are described in detail in the SPRINT programme report [1].

For each product the longitudinal shear resistance and allowable live loads are determined according to these regulations. Serviceability requirements and modes of failure other than longitudinal shear are not considered.

As an objective way of comparing the results of ultimate strength tests and to clarify the differences between the allowable design loads in the various countries, a statistical evaluation technique derived from EC3 [4] was used. This process enables a standard method to be used which provides the characteristic values, the design values and the values for the strength from tests which are in compliance with the basic safety assumptions of Eurocode 3 (chapter 2).

### 3. TESTS RESULTS USED FOR THE DETERMINATION OF THE LONGITUDINAL SHEAR RESISTANCE

Certain tests listed in table 1 could not be used for the determination of the longitudinal shear resistance, because either a flexural or shear failure occurred or the test procedure was incomplete.

Flexural failure was assumed to occur when the positive bending moment in the test reached 95% or more of the theoretical maximum bending moment ( $M_{max}$ ) capacity.

Vertical shear could influence the failure when the shear span length ( $l_{s2}$ ) of the test specimen subjected to two line loads was less than three times the slab depth.

### 4. DESIGN MODELS

Two design models are frequently used. One model is based on the partial connection theory and the other is the 'm and k' design model.

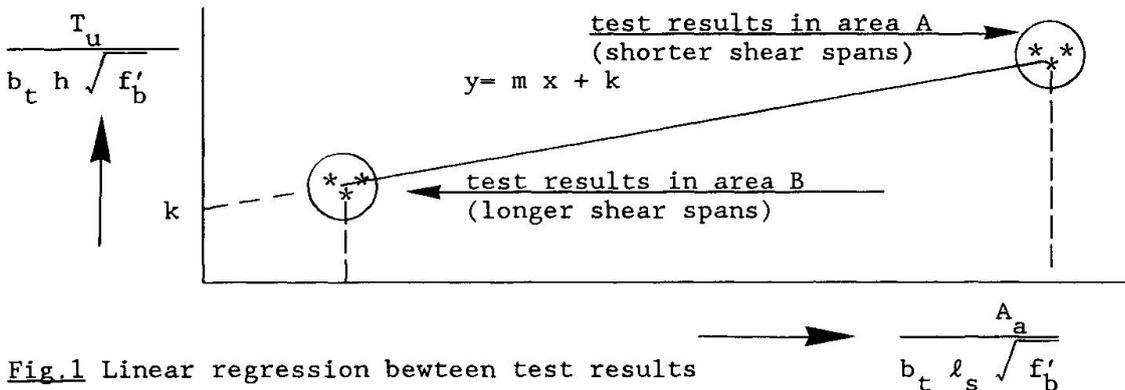


Fig.1 Linear regression between test results

The national regulations of the three countries involved in the research program are based on the 'm and k' method which is related to a linear regression line between test results:  $y = m x + k$  (Fig. 1)

This method, introduced by Porter and Ekberg [2], yields the following design expression which is used in BS 5950 Part 4 1982 and draft RSBV 1984.

$$\frac{T_u}{b_t h} = m \frac{A}{b_t l_s} + k \sqrt{f'_b} \quad (1)$$

where:

$m, k$  = factors that are derived from the regression analysis.

$f'_b$  = compressive strength of the concrete.

Similarly the Avis Technique expression is:

$$\frac{T_u}{b_t h} = m^* \frac{A}{b_t l_s} + k^* \quad (2)$$

The partial connection theory was used by Stark [3] for the design of the PRINS PSV 73 composite slab. The design model is similar to the one for composite beams.

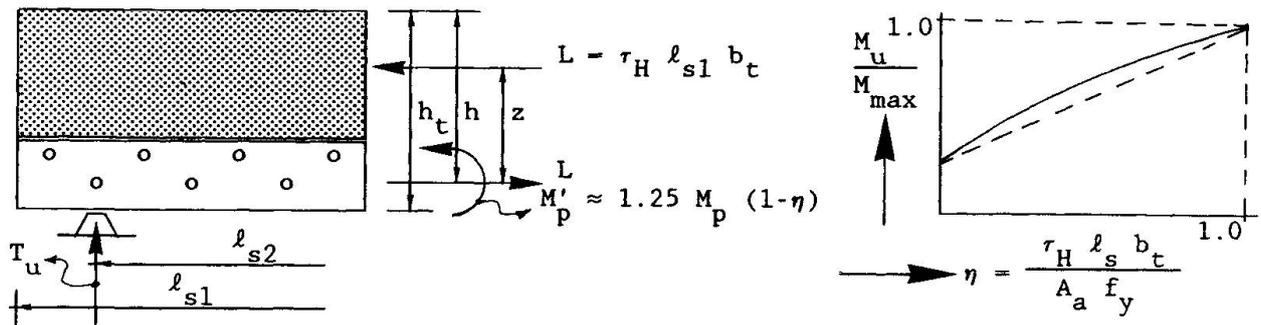


Fig. 2 Partial connection theory

Consideration of the equilibrium of the composite section and the assumptions:

$$\frac{z}{h} \approx 0.8 \quad \text{and} \quad \frac{l_{s1}}{l_{s2}} \approx 1.0, \quad \text{leads to:}$$

$$\frac{T_u}{b_t h} = f_y \frac{M_p}{M_{max}} \frac{z}{h} \frac{A_a}{b_t l_{s2}} + \tau_H \left( 0.8 - \frac{M_p}{M_{max}} \right) \approx m^{**} \frac{A_a}{b_t l_s} + k^{**} \quad (3)$$

where:

$A_a$  = cross sectional area of profiled sheet;

$b_t$  = width of the composite slab;

$l_s$  = shear span length ( $l_{s2} = l/4$  for simulated uniformly distributed load).

Equation (3) is similar in form to the 'm and k' form used in both the BS 5950 Part 4 and French Avis Technique. Depending in part of the evaluation carried out in these studies, a design model based on partial connection theory similar to the above may be included as an annex to EC4.

### 5. STATISTICAL EVALUATION OF TEST RESULT

For the 'm and k' method a statistical evaluation of test results has been performed. Procedure for the statistical evaluation will be briefly discussed.

The assumed 'theoretical' (semi-experimental) strength function  $r_t$  is:  $\bar{m} f_x + \bar{k} g_x$

In the 'theoretical' strength function the measured values for each test should be used, for the variables in the statistical evaluation.

The values for  $\bar{m}$  and  $\bar{k}$  are 'the best fit mean value' from a linear regression of the test results:  $y = \bar{m} x + \bar{k}$

$$\text{or: } \left( \frac{r_e}{g_x} \right) = \bar{m} \left( \frac{f_x}{g_x} \right) + \bar{k} \quad \text{or: } \frac{T_u}{b_t h \sqrt{f'_b}} = \bar{m} \frac{A_a}{b_t l_s \sqrt{f'_b}} + \bar{k}$$

where:

$r_e$  = the experimental resistance (support reaction in the test)

In a background report to EC3 [4] there is a description of how to determine:

$$\begin{aligned} \text{mean strength function} &: r_m = r_t \bar{b} \\ \text{characteristic strength function} &: r_k = R_k r_t \bar{b} \\ \text{design strength function} &: r_d = R_d r_t \bar{b} \end{aligned}$$

and furthermore:

$$\gamma_M = \frac{r_k}{r_d} \quad \text{and} \quad \gamma_M^* = \frac{r_n}{r_d}$$

The characteristic values for m and k are:  $m = \bar{m} \bar{b} R_k$  and  $k = \bar{k} \bar{b} R_k$

where:

$r_n$  = the nominal resistance (support reaction determined with the form in the regulations where  $f'_b$  is a characteristic strength).

In table 2, results are given of a statistical evaluation of the manufacturers test results, the Sprint-project test results and all usable test results together. For the design strength functions and values of  $r_d$  in area A and B determined with all usable test results see also fig.3.

country	profile	number of tests	$\rho$	$\gamma_M$	* $\gamma_M$	$r_d$ ( for $l = l_s$ )	
						area A	area B
NL(RA31)	SH	6	0.90	1.18	1.21-1.26	35.5 kN	50.4 kN <sup>2)</sup>
UK	SH	9	0.95	1.23	1.52-1.56	53.6 kN	54.3 kN <sup>2)</sup>
NL+UK+F	SH	14	0.99	1.14	1.29-1.33	40.2 kN	38.5 kN
UK(RA31)	COF	5	0.92	1.24	1.72-1.86	14.4 kN	10.6 kN
F	COF	6	0.91	1.16	1.40	12.1 kN	10.5 kN
NL+UK+F	COF	14	0.82	1.34	2.03-2.28	13.3 kN <sup>1)</sup>	7.9 kN <sup>1)</sup>
F(RA31)	PSV	6	0.82	1.11	1.12-1.17	38.1 kN <sup>1)</sup>	42.6 kN <sup>1)</sup> 2)
NL	PSV	6	0.99	1.10	1.17-1.19	34.8 kN	33.0 kN
NL+UK+F	PSV	11	0.99	1.12	1.20-1.24	33.7 kN	32.7 kN

1) Correlation factor  $\rho < 0.9$  does not comply with [4].  
 2) Depending on the yield strength of the profiled steel sheet there is a flexural failure in area B (longer span length).

Table 2 Results of the statistical evaluation.

## 6. CONCLUSIONS

From the statistical analysis it may be concluded that in the 'theoretical' (semi-experimental) strength function for the 'm and k' method the shear span length  $l_s$  should be  $l_{s2}$ . This leads to the best correlation and  $\gamma_M^*$  values which indicates<sup>s</sup> improvement<sup>s2</sup> of the 'theoretical' strength function.

Taking all the usable test results of COFRADAL together, results in a correlation factor less than 0.9 which does not comply with requirements of [4]. When the UK and F test results are evaluated separately the correlation is acceptable and the design values are within a small region. The different test procedures may influence this although it cannot be proved for the SUPER HOLORIB and PRINS profiled steel sheet. The 'm and k' design model does not recognize fully the more brittle failure mode of certain profiles.

The result of an investigation with a smaller number of tests does not differ significantly from the results with all usable test results together (see table 2). Often results in area B are influenced by yielding of the steel sheet and this variable is not included in the 'theoretical' strength function.

With respect to the SUPER HOLORIB test results it should be mentioned that the UK investigations were carried out with a sheet thickness of 1,0 mm and the NL investigations with 0.87 mm. This could explain the difference in the design values for area A.

country	profile	number of tests	BS 5950 Part 4		draft RSBV 1984	
			area A	area B	area A	area B
NL+UK+F	SH	14	36.8 kN	35.3 kN	39.5 kN	37.5 kN
NL+UK+F	COF	14	13.7 kN	10.4 kN	13.1 kN	11.3 kN
NL+UK+F	PSV	11	29.2 kN	26.4 kN	28.3 kN	24.7 kN

Table 3 Design value  $r_d$  according to the approximate evaluation method in the regulations.

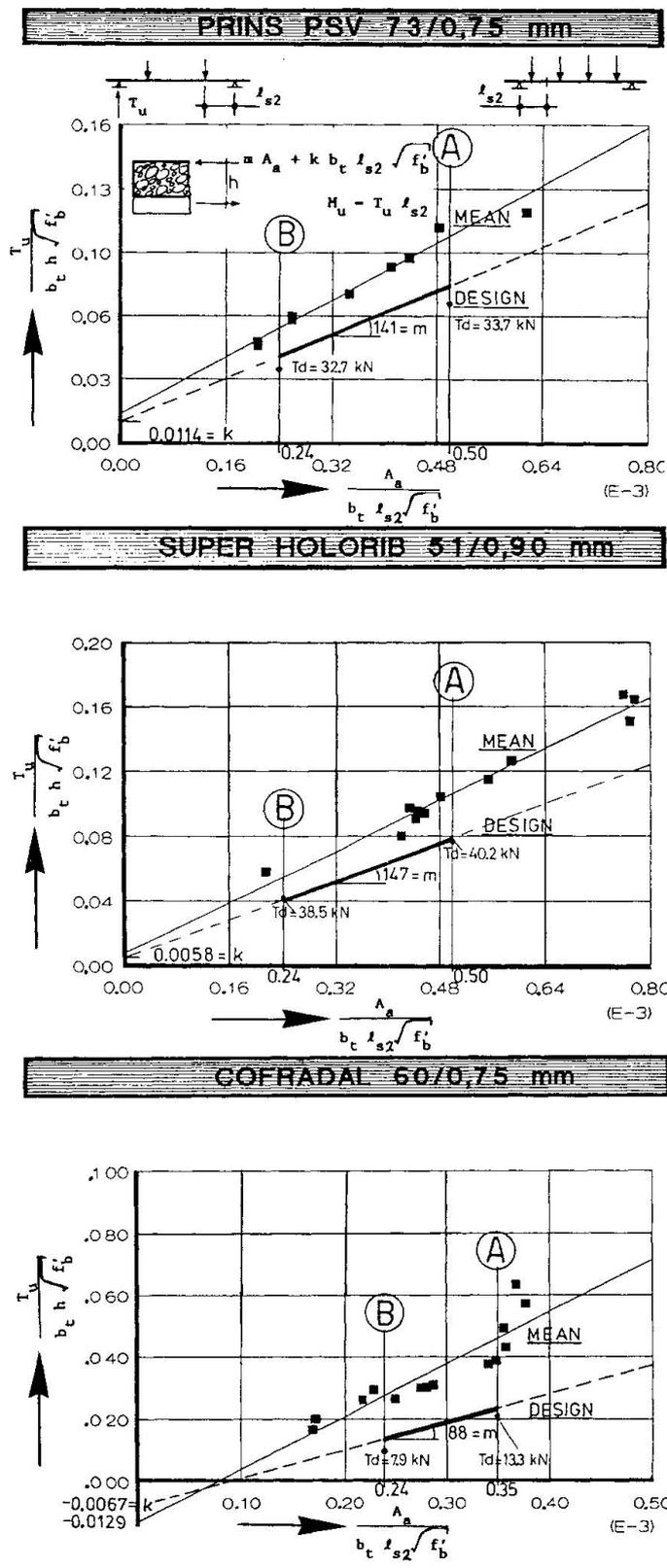


Fig.3 'Theoretical' and statistical determined (semi-experimental) design function of the profiles examined in the SPRINT-project RA31

If the correlation of test results is sufficiently good,  $\gamma_M$  can be taken approximately 1.25 according to EC4 (see table 2).

In table 3, results are given for the design value  $r_d$  for all usable test results according to the approximate evaluation method given in BS 5950 Part 4 and the draft RSBV 1984.

The approximate evaluation method in the BS 5950 Part 4 and the draft RSBV 1984 are useful (compare table 2 and 3). In general it is a safe approximation, which is more conservative for a large number of test results especially using the draft RSBV 1984 because the characteristic value is related to the lowest test result.

The statistical evaluation method described in this paper has been shown to be a very useful method for the evaluation of test results and provides an important 'instrument' for the development of a design model.

7. REFERENCES

1. O'LEARY/MOUM/BREKELMANS, A comparison of test procedures. University of Salford/CTICM/TNO-IBBC synthesis report No 90/237 of Sprint-project RA31, 1990.
2. PORTER/EKBERG, Compendium of ISU research conducted on cold-formed steel-deck-reinforced slab systems. Bulletin 200, engineering research institute Iowa State university Ames, Iowa, 1978.
3. STARK, Design of composite floors with profiled steel sheet. 4th-International specialty conference on cold-formed steel structures, department of civil engineering, university of Missouri, Rolla, 1978.
4. BIJLAARD/SEDLACEK/STARK, Procedure for the determination of design resistance from tests, RWTH-Aachen/TU-Eindhoven/TNO-IBBC report BI-87-112, November 1987, updated November 1988.