



THE HIGHWAYS AGENCY

BA 36/90



THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT



THE WELSH OFFICE
Y SWYDDFA GYMREIG



THE DEPARTMENT OF THE ENVIRONMENT
FOR NORTHERN IRELAND

The Use of Permanent Formwork

Summary: This Advice Note gives guidance on the use of permanent formwork in the construction of highway bridges.

VOLUME 2	HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS
SECTION 3	MATERIALS AND COMPONENTS

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**THE USE OF PERMANENT
FORMWORK**

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1. INTRODUCTION

1.1 Permanent soffit formwork provides a practical and economical way of supporting freshly poured insitu concrete in composite bridge decks.

1.2 Non-recoverable void formers are a different type of permanent formwork used to form cells or voids in insitu concrete slab decks in order to reduce dead weight.

1.3 Where a British Standard called up in this Advice Note specifies any physical requirement for the manufacture of permanent formwork such a requirement shall be satisfied by compliance with any relevant national or governmental standard of any member state of the European Communities provided the standard in question offers guarantees of safety, suitability and fitness for purpose equivalent to those offered by the British Standard specified. This proviso does not apply if the British Standard concerned implements or is technically equivalent to a European Standard.

2. SCOPE

2.1 This advice note contains information on the use and the limitations of different types of permanent soffit formwork for bridges. It also gives advice on the installation of void formers in bridge decks.

3. GENERAL

3.1 Permanent soffit formwork is part of the temporary works during deck construction, but when the deck concreting is complete and has become self supporting it then becomes part of the permanent works. The durability of the formwork and the effect which its presence has on the overall durability of the deck are therefore as important as its ability to carry the weight of wet concrete and cope with other constructional effects. The advice given in this document is based upon information gathered from surveys of existing bridges in which permanent formwork has been installed and on laboratory testing of some of the types of formwork of different materials.

3.2 Reference to any part of BS 5400, is to that part as implemented by the Department.

3.3 BS 5400: Part 5: 1979 classifies permanent soffit formwork into two groups, participating and non-participating. Examples of formwork from these two different groups are given in 3.3.1 and 3.3.2.

3.3.1. Participating formwork

i) Precast concrete units incorporating a welded lattice projecting into and providing shear connection with the overlying insitu concrete deck to form a composite deck slab. This is the only type of participating permanent formwork which has been used in bridges in recent years.

3.3.2. Non-participating formwork

i) Glass fibre reinforced cement (GRC) consisting of hydraulic mortars reinforced with alkali resistant glass is manufactured to give a range of sections designed to support various deck slab thicknesses and spans and manufacturers' catalogues show the commonly used sections. Single skin panels, either flat sheet or corrugated (Fig 1a), where the in-situ concrete is in contact with the GRC over the full surface area of the panel, are acceptable for use. The use of polystyrene formers in the corrugations is not permitted. Multi-skinned panels, such as those illustrated in Fig 1b, should not be used as panels of this type have failed in service and have not met laboratory test criteria.

ii) Glass reinforced plastic (GRP) is a flat laminated panel consisting of a resin mortar filling between two thin sheets of glass reinforced plastic. One surface of the panel has projecting steel reinforcing ribs on edge encased within the GRP (see Fig 2).

Generally these have performed satisfactorily although there have been isolated cases of corrosion of the steel ribs. This was due to incomplete covering by GRP material and was exacerbated by poor storage conditions of the steel prior to manufacturing the panels. Properly manufactured panels should not suffer from this problem.

GRP formwork should only be used with the ribs projecting into the insitu concrete deck slab. There should be no filler materials such as expanded polystyrene placed between the ribs, which would prevent full contact between the deck concrete and the surface of the ribbed panels.

iii) Profiled steel sheeting (PSS) is usually of the order of 1mm thick and is protected by galvanising with an additional polyester (plastic) coating. This material has not been widely used, but in a few instances corrosion to untreated cut edges and site damage to the coatings has been observed, although this has not seriously impaired the structural performance. PSS should not contain indentations which may form a shear connection with the insitu concrete, since there is a risk of fatigue cracking initiating from this detail.

iv) Asbestos cement panels were used successfully in the early 'M' and other precast beam type decks but have been superseded by other materials such as GRC or GRP.

v) Timber panels have been used in the past but are not now considered suitable for permanent soffit formwork.

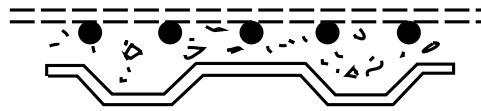
3.4 Three common types of void former have been used in the past in bridge decks:-

- i) Spirally wound corrugated steel tubes
- ii) Waxed cardboard tubes and boxes
- iii) Expanded polystyrene to any shape.

Current practice in new construction is to use iii).

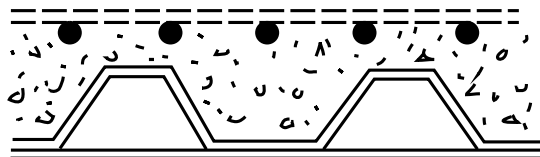


GRC Flat Single Skin



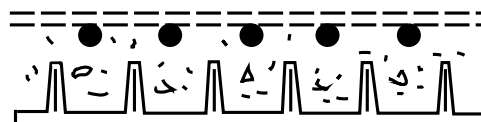
GRC Corrugated Single Skin

Figure 1a



GRC Multi-skinned

Figure 1b



GRP

Figure 2

4. DESIGN

4.1 Temporary Works Condition during Deck Slab Construction

4.1.1 Non-participating and participating formwork should be capable of supporting the sum of the following loads at the ultimate limit state:

- i) self weight of formwork
- ii) weight of wet concrete in the deck slab
- iii) a minimum superimposed load of 1.5kN/m^2
- iv) the effects of wind load where appropriate.

Note. BS 5975, Clause 27 describes the loads allowed for in the superimposed load and indicates the circumstances where the figure of 1.5kN/m^2 should be increased.

4.1.2 The formwork should be able to resist the effects of concentrated loading e.g. due to reinforcement spacer blocks or operatives walking on the reinforcement.

4.1.3 For satisfactory performance of non-participating formwork at the ultimate limit state the following conditions should hold:- $R^* > 2S^*$, where R^* is the design resistance based on the characteristic (or normal) strength of the formwork f_k and S^* is the design load effect due to the above nominal loads. (In this calculation the partial factors Y_{fL} , Y_{f3} and Y_m as defined in BS 5400 are all to be taken as equal to 1.0).

4.1.4 In the case of participating permanent formwork the design requirements for precast concrete units with appropriate shear connection to the composite insitu concrete are given in BS 5400: Part 5.

4.1.5 Section and material properties for proprietary permanent formwork should be obtained from the manufacturer's published data.

4.1.6 Load testing should be carried out on site by the Contractor to demonstrate the ability of the proposed permanent formwork to support the prescribed loading without exceeding the deflection limit. Alternatively load testing may be carried out at the manufacturers works provided that;

- (a) the tests are equivalent to those specified in the contracts; and
- (b) the tests are undertaken or supervised by a testing house offering suitable and satisfactory guarantees of technical and professional competence and independence.

4.1.7 Deflection of permanent formwork 4 hours after completion of concreting should not exceed $1/300$ of the span of the formwork unit. In assessing deflection, allowance should be made where necessary for creep.

4.2 Permanent Works Condition after Deck Slab Completion

4.2.1 In assessing the durability of non-participating permanent formwork any residual stresses in the formwork resulting from the deck slab construction should be combined with the stresses induced by the subsequent cyclic highway live loading.

4.2.2 Participating permanent formwork should be designed for the effects of composite action with the insitu deck slab in accordance with BS 5400: Part 5 cl 9.5.3.

4.2.3 In the design of deck slabs incorporating non-participating permanent formwork, cover, crack widths etc must be calculated on the basis that the formwork is not present. (BS 5400: Part 5 cl 9.5.2). The minimum cover to the reinforcement of the deck slab should be taken as that measured to the nearest formwork element, ie to the top of the rib for a GRP panel and to the top of the corrugations for a steel or GRC corrugated panel.

4.2.4 Where corrugated or profiled sheeting is used which provides a downward projection of the insitu concrete the calculated crack width at the lowest surface shall not exceed 0.5mm. (See Fig 3)

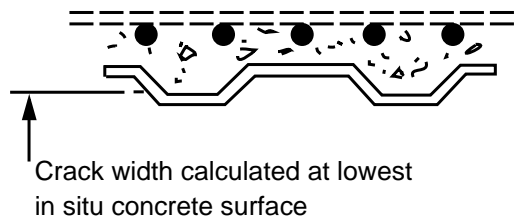


Figure 3

5. DETAILING, CONSTRUCTION AND WORKMANSHIP

5.1 Protective paint systems to main steel members should be continued 25mm beyond a point on the upper edge of the top of the section, where the compressible construction seal for the formwork is located as shown in Figure 4. On completion of the curing of the deck slab in steel/concrete composite bridges a suitable proprietary sealant compatible with the formwork and paint system and of comparable durability should be injected between the edge of the flange and the soffit of the permanent formwork to prevent ingress of moisture.

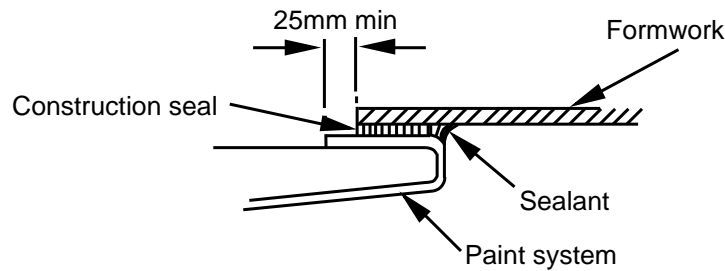


Figure 4

SEALING DETAILS AT EDGE OF STEEL BEAM

5.2 Where there are splice plates or any other discontinuities in the flanges of the main beams detailing of permanent formwork and its sealing needs special attention. For example difficulties have been reported in sealing the gaps between individual formwork units and between units and main girders when precast concrete formwork units have been used.

5.3 Cut edges of PSS panels will require special protective treatment comparable with the original protection.

5.4 Positive fixing of non-participating formwork may be required to prevent uplift from wind or to prevent it being dislodged accidentally from its seating during construction.

5.5 Checks should be carried out on site to ensure that the rebates in precast concrete beams which are intended to receive the permanent formwork have been well formed and that any dressing-off is carried out before placing the formwork to ensure an even seating.

5.6 Before accepting a particular type of formwork the manufacturers dimensional tolerances should be ascertained. Panels which vary from the manufacturers stated dimensions by more than the tolerances should be rejected.

5.7 Panels should be handled with care at all times. Those which are cracked, split or have, in the case of GRP type, exposed steel in the ribs should be rejected. Also panels which are cracked during preparation for concreting should be replaced.

5.8 Formwork panels should be thoroughly cleaned to remove all traces of oil or grease. Any GRC panel which cannot be cleaned by following the manufacturers recommendations should be replaced since it is important not to damage the bond between panel and insitu concrete.

5.9 Concrete should neither be allowed to accumulate in heaps nor be dropped from heights greater than described in BS 5975: Clause 27.3.1, and storage of materials on permanent formwork should not be permitted unless these have been specifically taken into account in the design and are clearly indicated in the Contract documents.

5.10 The concrete mix for the insitu deck slab should be designed with a sufficiently high workability to ensure that with normal compaction methods the concrete will fill the formwork and completely surround the reinforcing steel. Cases have been reported where partial removal of the permanent formwork for inspection has revealed that poorly compacted and honeycombed concrete has been cast against permanent formwork, resulting in the risk of corrosion of the reinforcement.

5.11 Sealing arrangements should be grout tight under all conditions.

6. VOID FORMING

6.1 Proprietary void formers in deck slabs should be installed in accordance with the manufacturers instructions. Fixings should be well anchored and sufficiently strong to resist the effects of uplift from the wet concrete and any surging from discharged concrete.

6.2 Joints between adjacent units, or units and form faces should be sealed to prevent loss of grout.

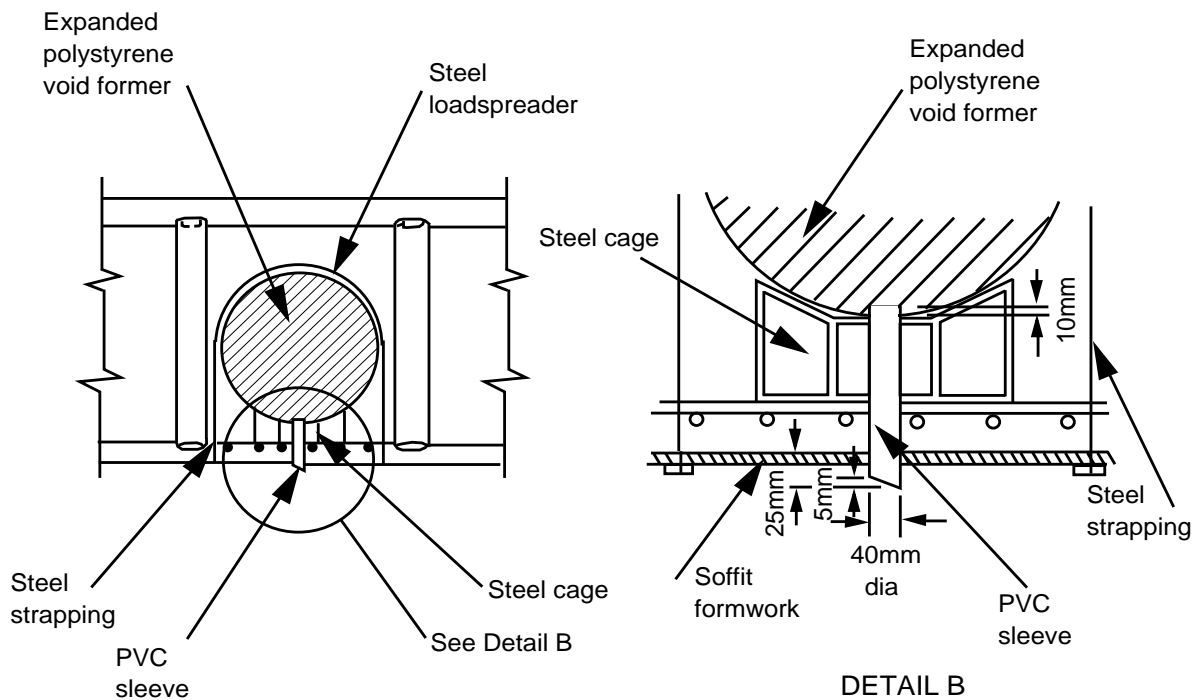


Figure 5

DRAINAGE IN NEW VOIDED SLAB BRIDGES

Note; One method is shown for positioning the void former and securing it against flotation but other methods may be employed

Note: One method is shown for positioning the void former and securing it against flotation but other methods may be employed.

6.3 All voids should have drainage provision. A 40mm nominal diameter hole formed by cast-in p.v.c sleeving near the lower end of each void on its centre line should be provided. The sleeving should project 25mm below the bridge soffit without encroaching on minimum headroom requirements as shown in Figure 5 for a circular voided slab. The sleeve requires to be positively fixed and the joint between the void former and the sleeve should be grout tight. On completion of the works the drainage pipes should be checked to ensure that they provide a clear passage into the void.

7. REFERENCES

Reference to any part of BS 5400, is to that part as implemented by the Department.

1. BS 5400 Steel, concrete and composite bridges.
Part 5: 1979 Code of practice for the design of composite bridges.
2. BS 5975: 1982 Code of practice for falsework.

8. ENQUIRIES

Technical enquiries arising from the application for this Advice Note to a particular project should be addressed to the appropriate Technical Approval Authority.

All other technical enquiries or comments should be addressed to:

Head of Bridges Engineering Division
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Southwark Street
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