The Designers' Guide to the use of Expamet Hy-Rib

Expamet Building Products Ltd., PO Box 52, Longhill Industrial Estate (North), HARTLEPOOL, Cleveland TS25 1PR, England

Tel: +44 (0) 1429 866 655

Fax: +44 (0) 1429 866 633

email: enquiries@hy-rib.com

www.hy-rib.com

Third Edition December 2004

Contents

Key Product Features

Introduction

Expamet Hy-Rib used as permanent formwork has evolved from its proven record in worldwide use on construction joints. Expamet Hy-Rib used as permanent formwork in construction joints minimises surface preparation and **reduces the risks involved with hand and arm injuries** (white finger) (See page 4 of this Guide and Ref. 23).

When concrete is poured behind it, the angled tabs of the mesh become embedded producing a mechanical bond. Tests (Refs. 4, 19 and 20) have confirmed that the subsequent joint is stronger in flexure, bond strength and shear than a conventionally prepared joint with exposed aggregate. Examination of cores taken through the joint have confirmed the well compacted concrete to both sides of the Hy-Rib joint, particularly at the laps. See page 28.

Where the final finish is not required as fair faced, the significant reductions in concrete pressure can be utilised to provide economic and fast, wall and column construction.

Whether double faced, single faced, curved, lost formwork or underwater, Hy-Rib when compared to traditional methods, gives considerable performance and economic benefits to formwork in the construction industry.

For further reading refer to the industry's main source of reference for formwork design, the Concrete Society document "Formwork - a guide to good practice" (Ref. 8)

Principle Benefits

- Hy-Rib reduces significantly the pore water pressure in the design concrete pressure normally associated with conventional stop end materials of timber, plywood or steel.
- Hy-Rib is colour coded. This identifies the product and gives a simple, quick and effective way for the site to check that Hy-Rib is installed the correct way, see Page 22.
- Hy-Rib is left in place and forms an ideal surface for subsequent concrete. This means that scabbling of the face is not necessary. See HS(G) 170 (Ref. 23)
- Minimises joint preparation so that reinforcement fixing continues uninterrupted. See Page 23. The only striking required might be the timber cover strips, and any timber supports used as backing.
- Trials (Ref. 19) have shown that even with high workability concrete, with significant bleeding, such as sometimes experienced with use of 60% cement replacement with ggbs, the use of Hy-Rib did not have any detrimental effect on the concrete.
- Can either be placed before or after the reinforcement is fixed. If before, the reinforcement is then installed through holes pierced in the mesh; if afterwards, it is readily cut to accommodate the position of the bars.
- Allows the progress of the pour to be visually monitored, thus reducing the risk of voids and honeycombing.
- To obtain maximum economic advantage, Hy-Rib is best supported by existing or extra reinforcement bars. See Figure 3. This allows the whole fabrication to be left in place, eliminating most striking operations for the joint - particularly useful in congested areas of reinforcement.
- In the unlikely event of a large concrete pour being interrupted or delayed, such as by bad weather or interruption of concrete supply, Hy-Rib is the IDEAL material as a standby to form any shape of contingency stop end. Its benefit being that construction can quickly be resumed, without striking the temporary stop end. As a contingency, clients can specify Hy-Rib be made available on site prior to commencing large pours, in the knowledge that un-planned stop ends can quickly be constructed.
- Hy-Rib with the concrete creates an ideal bonding surface for the subsequent pour.
- Correct cover to the Hy-Rib, similar to the reinforcement, is easily provided using timber or plastic strips, wired to the reinforcement or directly fixed to the soffit or face material

Extract from HS (G) 170

32 SPECIAL FORMWORK AVOIDS SCABBLING

The task

Construction of large concrete structures.

The problem

A construction company was awarded a contract to build one of the stations for the London Underground Jubilee Line Extension. The station design included a reinforced concrete base slab 300 m long, 25 m wide and 3 m deep. The slab was cast *in situ* in 43 sections, each 7 m long. The sections were cast one after another using the previous section to support one side and a specially constructed formwork stop end to support the other. With this method of construction it is important that the new concrete makes an effective bond with the old. When wooden formwork is used, this bond can only be achieved by removing the top surface of the concrete to reveal the aggregate underneath. This is often done with impulsive tools in a process known as scabbling. In this case, the tools were used for about 2 hours per day and exposed operators to high vibration magnitudes (typically 15 m/s^2). At that work rate, each stop end would have taken approximately eight worker shifts to scabble with a vibration exposure of about 8 m/s^2 A(8).

Scraping away excess material during pouring

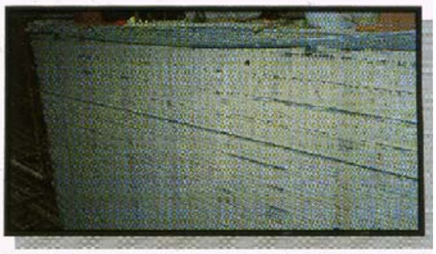
The solution

The company used an expanded metal material to construct the formwork for the stop end mating surfaces. The material was ribbed and featured bent tabs of mesh which, when concrete was poured behind it, become embedded in the concrete, forming a bond. The formwork was left in place once the concrete had cured and when the next section was poured, it formed a bond with the outer surface of the expanded metal that was as strong as a traditional scabbled joint. No scabbling was necessary.

The result

- The operators were not exposed to any vibration.
- It was installed more quickly than using wooden formwork as it allowed the next section of concrete to be poured before the previous section was fully cured (set).
- Noise and dust levels were also reduced.

Case courtesy of Tarmac Bachy Joint Venture



Example of *in situ* cast concrete showing expanded metal formwork

	Vibration magnitude $a_{h,w}$ in m/s^2	Time before daily exposure exceeds 2.8 m/s^2 A(8)	Daily exposure time	Daily exposure (m/s^2 A(8))
Before (estimated)	15	17 minutes	2 hours	7.5
After	0		0	

Product Data

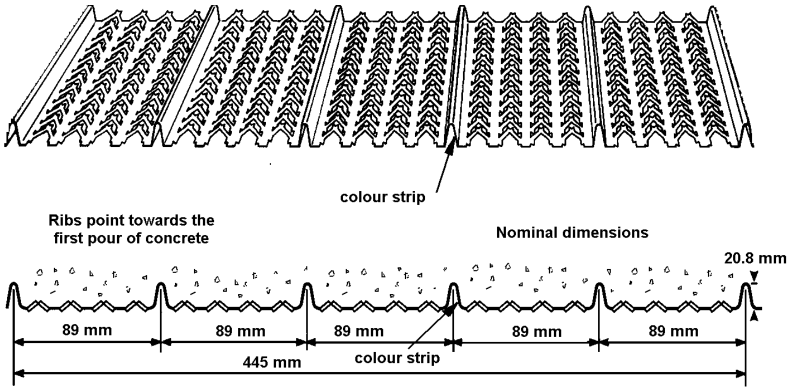


Fig. 1 Illustration and Cross section of all grades of Hy-Rib

Expamet Hy-Rib is manufactured from pre-galvanised steel sheet to BS EN10142 (Ref. 1). Three grades of Hy-Rib are available. Although formed in identical ways, each grade is made from a different material thickness to give the user a choice of structural properties. See **Table A**. The three grades of Hy-Rib are known as grades 2411, 2611 and 2811. Figure 1 illustrates the shape and cross section of all grades of Hy-Rib.

Expamet Hy-Rib is colour coded with a coloured strip on the inside of one rib as shown at Figure 1 above; Grade 2411 is yellow, 2611 is green, and 2811 is red.
The shape and cross section of a Hy-Rib sheet is illustrated in Figures 1 and 2.

Property	**units**	**Grade 2411**	**Grade 2611**	**Grade 2811**	**Comment**
Colour Code	strip	**Yellow**	**Green**	**Red**	
Weight per area Weight per metre	kg/m² kg/m	6.34 2.82	4.23 1.88	3.39 1.51	/m² /m sheet
Sheet width	mm	445	445	445	Nominal
Available lengths	m	2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5	other lengths available if pre-ordered
Section modulus Z_{joint} Z_{span}	mm³/m mm³/m	1710 2233	1125 1488	952 1266	Rib in tension Face in tension
Moment of resistance (working) (fZ)	kNm/m kNm/m	0.330 0.431	0.217 0.287	0.184 0.244	At the supports (rib away from load) At midspan (rib towards load)
Bending stiffness (EI) Working max. reaction Assumed maximum working shear	kNm²/m kN/m kN/m	3.94 19.94 9.97	2.53 14.90 7.45	2.00 10.88 5.44	See notes See notes See notes

TABLE A : Properties of Expamet Hy-Rib.

NOTES to Table A

1. The properties assume that the Hy-Rib is used with the ribs pointing into the concrete to be placed, and spanning in the strong direction between supports with the ribs parallel with the span.
2. The Hy-Rib is considered a single use sacrificial material with a minimum factor of safety of 1.4 on ultimate failure. The failure stress being the minimum ultimate tensile strength of the Hy-rib sheet material.
3. The bending stiffness values should only be used for estimating deflections. They allow for the complex geometric changes in properties and shape as Hy-Rib deflects.

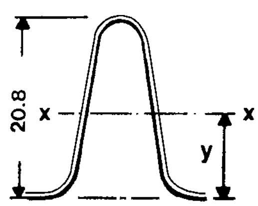


Fig. 2 Section of a Rib

How to use this Guide

Hy-Rib is used on site as permanent formwork to contain fluid concrete and retain it in position until it has stiffened and become self supporting. Hy-Rib is a one use material, and the stresses and design assumptions in this Designers' Guide take this into account.

The way it is used, supported and loaded by the concrete will affect the safe distance that it can span between supports. The design criteria for the Hy-Rib is generally the clear distance between the supports and is shown diagrammatically at Figure 3.

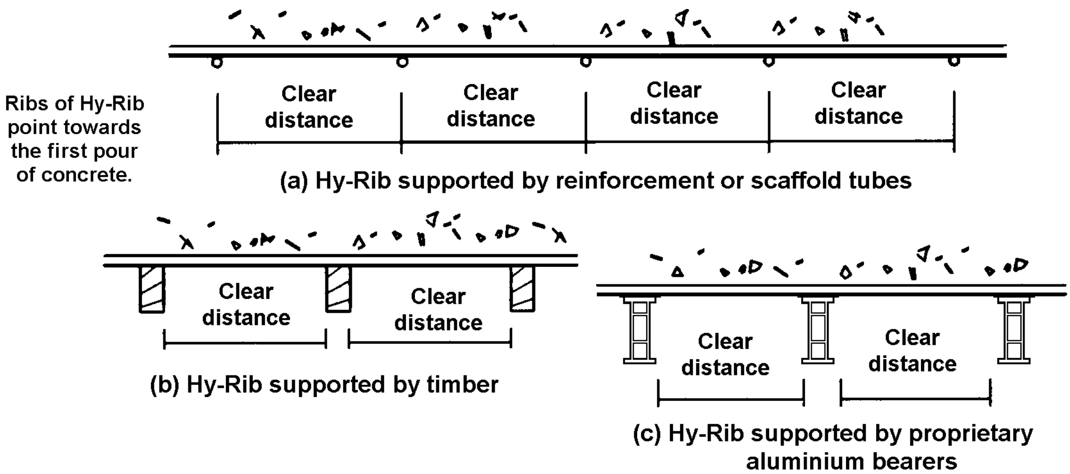


Fig. 3 Various methods of support to Hy-Rib

Expamet Building Products have carried out extensive research work into the structural properties and concrete pressures associated with Hy-Rib. The main trials were carried out at the British Cement Association (BCA) and at Taywood Engineering (TWE). The results are summarised at pages 26 and 27. The nomenclature used in this guide is to refer to the BCA trials on 5m high walls as "Wall One" etc., and the TWE trials on 2.225m high walls as "Panel One" etc. The tabular design methods shown in this design guide have assumed that the full concrete pressure is reduced as summarised at pages 24 and 25.

Temporary works designers may be aware that under certain conditions, the full concrete pressure, as calculated from a full density head of concrete may not be achieved. Guidance on establishing the shape of the concrete pressure diagram, together with Hy-Rib design information in such cases is discussed in more detail at page 25.

The ways and orientations in which Hy-Rib can be used are : -

To assist readers, a selection of questions and answers, together with examples are shown on pages 32, 33 and 34 of this guide.

Work on Site :

As Hy-Rib can be used with all conventional support systems, the following recommendations are given to assist planners and users to make the most economic use of the material. It is a proven system on site, and the following guidance is intended for those unfamiliar with its use.

Fitting details

Hy-Rib can be installed with the ribs placed either horizontally or vertically. The coloured identification stripe should be visible when viewed from the support side of the Hy-Rib. See Figure 5. The supporting members should always be at right angles to the ribs.

Hy-Rib should be securely attached to the supporting framework, either by tying wire, if reinforcement, or by nailing if timber or aluminium supports are used.

Where possible, the Hy-Rib should be visible, so that during the concrete placing operation, the vibration and formation of the concrete face suitable for the subsequent pour can be observed. See Figure 4 and 5. It is recognised that in certain applications, such as "lost formwork" this would not be possible.

The ribs should always point towards the first concrete to be placed against the Hy-Rib. See Figures 1 and 5.

***** The coloured strip should be visible before casting. *****

It is recommended that operatives handling Hy-Rib should wear appropriate protective equipment.

Where required, Hy-Rib is easily cut on-site with heavy duty shears or abrasive disc saws. Always follow the saw supplier's instructions.

Adjacent sheets should be side lapped by overlapping the outer edge ribs and tying together at about 150mm intervals. See Figure 4.

Length ways, sheets should overlap by minimum of 50mm and be supported. See Figure 4.

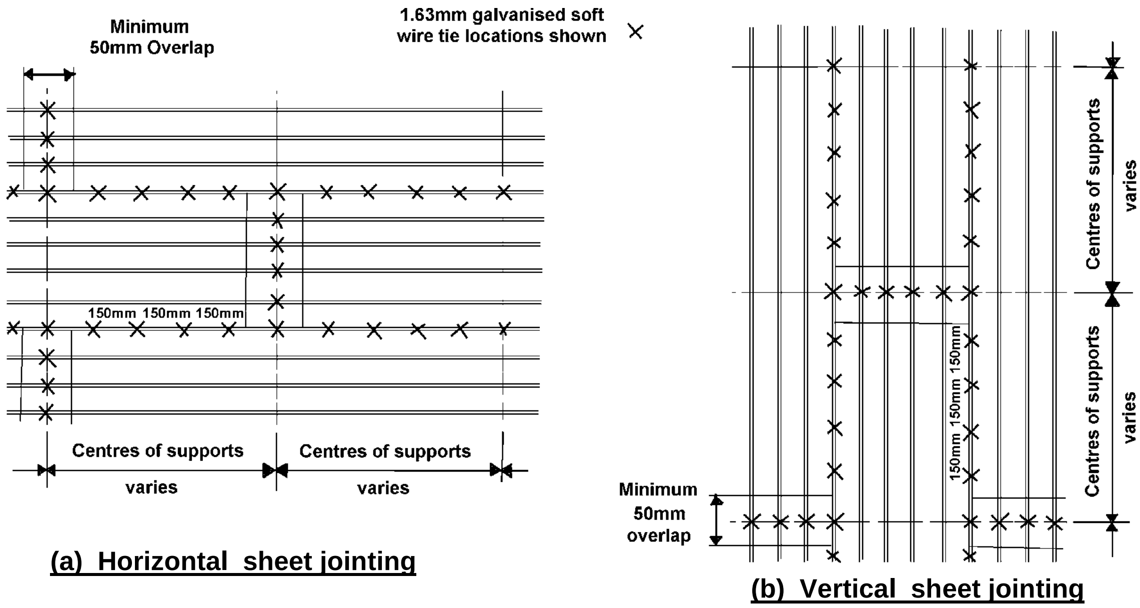


Fig 4 Typical Hy-Rib sheet jointing details.

Hy-Rib in reinforced concrete structures will normally be required to have the same nominal cover to steel as the reinforcement. This depends on the exposure conditions of the structure. Timber strips usually provide this cover. The use of such strips are illustrated in Figs 7 and 8.

Work on Site continued

Concreting details

Most types of mix can be used, and placement methods can vary, from pumped, to skipped, or directly placed. Concrete of Groups 1 to 7 can be used, see page 24. If possible the range of the likely concrete slump at time of placing should be between 70 to 100mm. Slumps up to 180mm can be used by limiting the use of the vibrator near the Hy-Rib face. Figure 6 shows a stop end used with self compacting concrete.

Concrete should, ideally, be placed 500mm away from the face and allowed to flow up to the Hy-Rib. Internal vibrators should be kept 450mm away from the Hy-Rib. Vibrate until a concrete face suitable for the subsequent pour can be observed, as shown at Figure 5. This creates an ideal bond formation at the Hy-Rib surface. If continuous vibration is used, keep the vibrator about 450mm from the face, but if it must be closer, limit it to five second bursts until the cement grout is observed coming through the open mesh.

When used as soffit formwork it is recommended that hand tamping be used.

External vibrators are not recommended for use with Hy-Rib.

When concreting has finished, there may be some build up of excess grout on walings and supports. It is good practice to lightly brush and/or wash these off before the concrete has hardened, but taking care not to disturb the concrete on the face.

colour identification strip (ie yellow = 2411 See Table A)

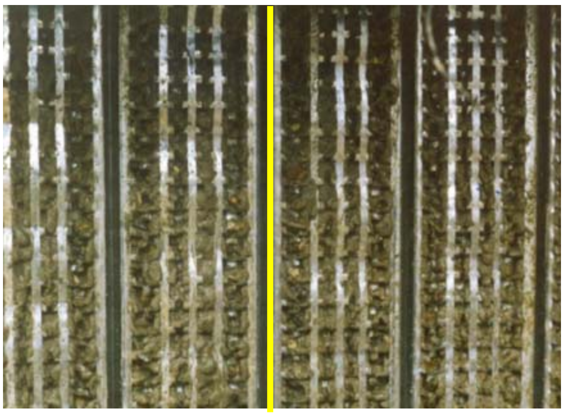


Fig. 5 View of CEM1 concrete formed through the Hy-Rib 2411 mesh

Fig 6 View of 360 deep stop end with self compacting concrete

Curing concrete

"Curing is the last - and one of the most important - stages of concrete construction" is a quote from the BCA booklet "Concrete on Site No. 6 - Curing". (See Refs. 10 and 11.) The reason for curing is to ensure that the cement continues to harden after it has been poured, by keeping sufficient water in the concrete. If curing is needed it should be started earlier than conventional formwork. The use of the spray-on curing compounds is not recommended on joints and stopends to which a further pour is to be connected.

Preparing the joint for the next pour

Remove timber cover strips (See Figures 7 and 8) and prepare the exposed concrete band. The Hy-Rib surface needs no further preparation and the Hy-Rib must not be removed. See also the BCA booklet "Concrete on Site No. 7 Construction Joints" (Ref. 10)

Construction Joints :

Slab joints and stop ends

In a slab construction joint or stop-end, up to 3m deep, the Hy-Rib will generally be placed horizontally with the supports vertical. The concrete pressure diagram will be triangular in shape up to 3m depth of joint, and will be zero at the top increasing to a maximum at the bottom. The safe clear distance between the supports is given in **Table B** which takes into account the triangular pressure variation.

Typical arrangements of joints when used with additional "U" shaped reinforcement bar supports are shown in Figure 7, and with timber supports in Figure 8 using suitable timbers. It is assumed that there is both a top and a bottom mat of reinforcement. Where the slab thickness is large, it may be necessary to introduce intermediate levels of support to reduce the load in each of the supports.

Using additional reinforcement the clear span will be the centres of the supports, see Page 6 Figure 3 (a). These bars should have an adequate horizontal return at both top and bottom, and be securely wired to the continuous horizontal reinforcement. When using timber, the centres of supports will be the value of the clear span **PLUS** the thickness of the timber supports, see Figure 3 (b). Adequate wedging of the timber against the existing reinforcement is needed, and the tying of the reinforcement should be checked to ensure that it will restrain the forces.

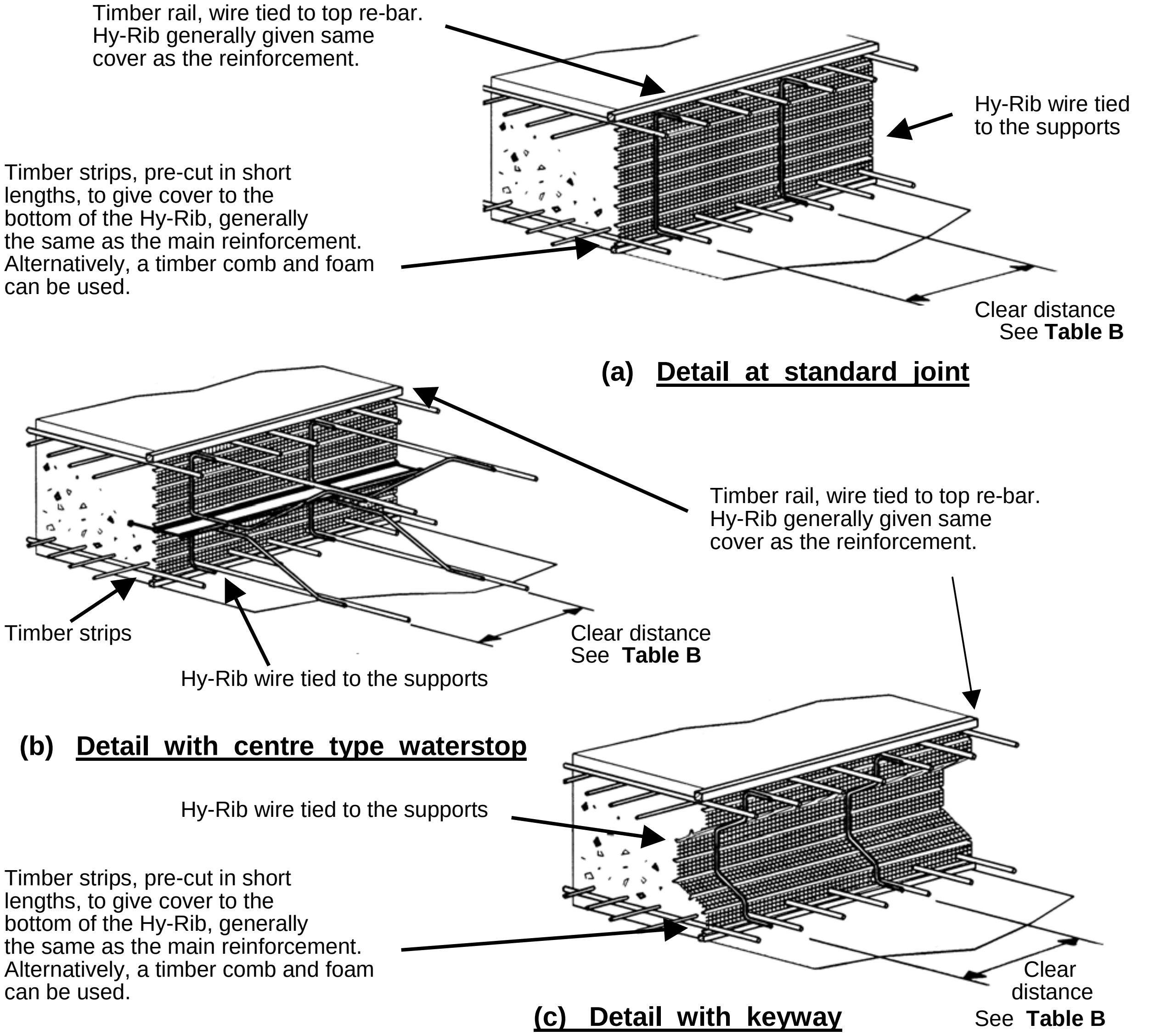


Fig. 7 Typical details of support to Hy-Rib using reinforcement.

Overall depth of slab joint	Max. concrete pressure		Clear Hy-Rib distance between supports		
	Theoretical* Table 2 CIRIA 108	assumed for Hy-Rib	Grade 2411	Grade 2611	Grade 2811
Mm	kN/m²	kN/m²	mm	mm	mm
250	6.25	3.20	1250	1025	950
500	12.50	6.30	900	725	675
750	18.75	9.50	725	600	550
1000	25.00	12.70	625	500	475
1250	31.25	15.80	575	450	425
1500	37.50	19.00	525	425	400
2000	50.00	25.30	450	375	350
2500	62.50	31.70	400	325	300
3000	75.00	38.00	375	300	275

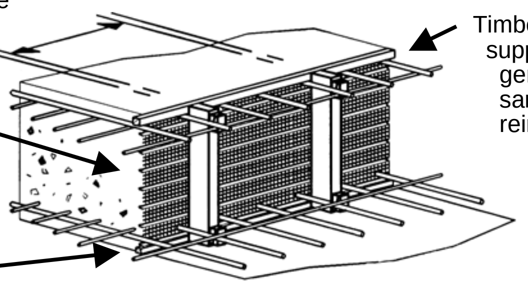
Table B : Indicative clear distance between supports at slab joints

NOTES to Table B.

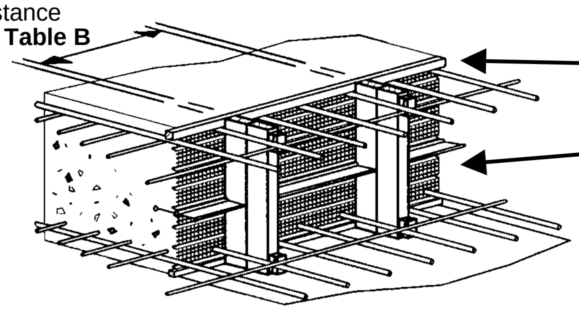
1. The Hy-Rib is used in horizontal sheets with the ribs pointing into the concrete to be placed, and spanning in the strong direction between vertical supports as typically shown in Figures 7 and 8.

2. * The theoretical maximum pressure is that calculated using Table 2 in CIRIA Report 108 (Ref. 2) with a concrete density of 25 kN/m^3, for EITHER a wall, a base or a column; AND applies to concrete Groups 1 to 5 inclusive. (See page 24 when using Groups 6 & 7)

3. The Hy-Rib pressure diagram up to 3m in height of joint is assumed to be triangular, as shown a Fig. 23 (a) and 23 (b). The permissible spans calculated from an uniformly applied concrete have been increased by a factor of 1.2 to allow for the triangular shape of the concrete pressure diagram. The maximum pressure only applies at the very bottom of the slab joint.



(a) Detail at standard joint



(b) Detail with centre type waterstop

NOTE: Correct cover to the open edge of the Hy-Rib such as at junction with edge forms, is not shown , and will normally be same as cover to reinforcement

Fig. 8 Typical details of support to Hy-Rib using timber.

Deep Construction Joints : Hy-Rib placed vertically

When Hy-Rib is used with the ribs running vertically, the supports (walings) will be placed horizontally. This arrangement usually occurs on deep stop-ends. The method of supporting the walings can vary, from propping off the slab as single faced forms, by securely attaching to the reinforcement, or by tie rods passing through the pour. Typical examples of its use on deep stop ends are shown at Figures 9 and 10 which assume that restraint to the vertical soldiers is by tie rods, connected to suitable restraints.

In all cases, the span of the Hy-Rib will vary according to the concrete pressure. **Table C** gives the safe clear vertical distance between the horizontal supports (walings) for different concrete pressures.

Concrete pressure		**Safe clear vertical distance between the Hy-Rib supports**		
Theoretical* Table 2 CIRIA 108	assumed for Hy-Rib	**Grade 2411**	**Grade 2611**	**Grade 2811**
kN/m²	kN/m²	mm	Mm	mm
6.25	3.20	1050	850	800
12.50	6.30	750	600	575
18.75	9.50	625	500	475
25.00	12.70	525	425	400
31.25	15.80	475	375	350
37.50	19.00	425	350	325
50.00	25.30	375	300	275
62.50	31.70	350	275	250
75.00	38.00	325	250	225
100.00	38.00	325	250	225
125.00	38.00	325	250	225
150.00	38.00	325	250	225
175.00	38.00	325	250	225

Table C : Safe clear span of Hy-Rib fitted vertically between supports

NOTES to Table C.

1. The properties assume that the Hy-Rib is used with the ribs pointing into the concrete to be placed, and spanning in the strong direction between the supports with the ribs parallel with the span. The Hy-Rib face is nominally vertical.

2. * The theoretical pressure is that calculated using CIRIA Report 108 (Ref. 2) with a concrete density of 25 kN/m³, for EITHER a wall, a base or a column; AND applies to concrete Groups 1 to 5 inclusive.

3. It is assumed that the Hy-Rib is simply supported. Even if the Hy-Rib is spanning over several horizontal supports (walings), its lower bending strength at the support is such that it will yield as the design concrete pressure is applied, making the bending at mid-span more critical when analysed as a simply supported member.

Deep Construction Joints : Hy-Rib placed vertically continued

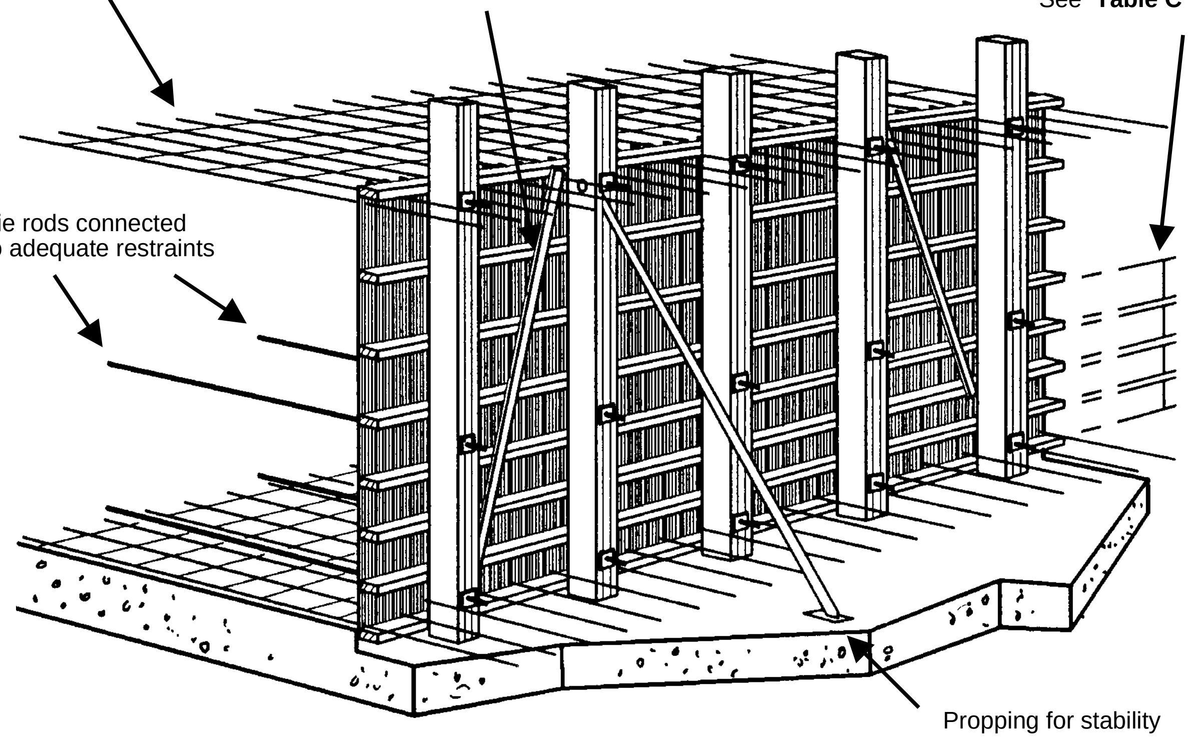


Fig. 9: Typical arrangement of deep construction joint with tie rods and Hy-Rib vertical.

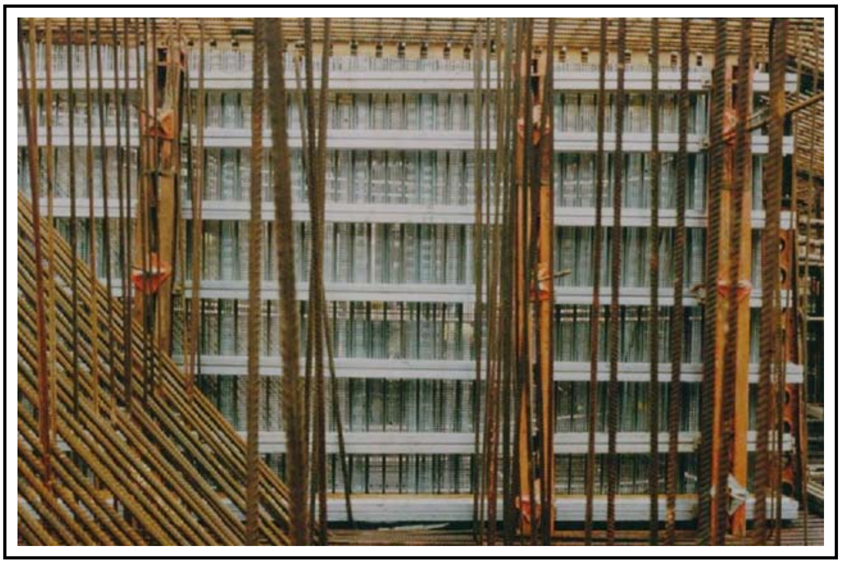


Fig. 10 Application of Hy-Rib to 3m deep stop end.

(Tees Barrage Client: Teeside Development Corporation
Contractor: Tarmac Construction Ltd.)

A typical application of the use of Hy-Rib on a deep stop end is shown at Figure 10. The project was the construction of the River Tees Barrage and the concrete pressures were measured by the British Cement Association (Ref.18). The research confirmed that there was a significant reduction in the concrete pressure on the Hy-Rib over that assumed from the CIRIA Report 108.

Construction Joints to Walls :

Vertical joints in thin walls : Hy-Rib placed vertically

In stop ends to thin walls (less than 900mm thick), the Hy-Rib will often be fixed to span vertically with the supports fitted horizontally. The concrete pressure diagram may not be uniform and will reduce near to the top, so that the distance between supports can increase in the top 3m of the pour.

The Hy-Rib is fitted with the ribs running vertically, as typically shown in Figure 9. The horizontal supports will usually be of timber and may be secured from the formwork face. The vertical centre to centre spacing of these supports will depend on the concrete pressure and the grade of Hy-Rib used. **Table D** gives an indication of the likely centres of the supports, measured from the TOP of the wall. The numbering of the supports is shown in Figure 9; as the pressure increases down the wall so the vertical spacing reduces until approximately 3m down from the top, at which point the pressure of the concrete on the Hy-Rib reaches the maximum design pressure of 38kN/m². See also Figure 23 (d).

Position of the support measured from the top of the wall	Centre to centre spacing of the supports (mm) and the approximate height of wall (mm)					
	Grade 2411		**Grade 2611**		**Grade 2811**	
	support spacing	approx. wall height	support spacing	approx. wall height	support spacing	approx. wall height
1						
	650		575		550	
2		see note 5		see note 5		see note 5
	575		525		500	
3						
	525		475		450	
4		1750		1575		1500
	475		425		400	
5		2225		2000		1900
	425		375		375	
6		2650		2375		2275
	375		325		325	
7		3025		2700		2600
	375		300		275	
8		3400		3000		2875
	375		300		275	
9		3775		3300		3150
	375		300		275	
n		4150		3600		3425
	etc	etc	etc	etc	etc	etc
Load in the supports	**approximately 14.3 kN/m**		**approximately 11.4 kN/m**		**approximately 10.5 kN/m**	

Table D : Indicative spacing of vertical supports to Hy-Rib supports to a vertical joint in a wall.

NOTES to Table D.

1. The Hy-Rib is used in vertical sheets with the ribs pointing into the concrete.
2. The value of support spacing is measured centre to centre of the vertical supports and is NOT the clear distance.
3. The supports to the Hy-Rib are horizontal and are a minimum of 50mm wide.
4. The approximate load per metre of the supporting members is given as a guide only.
5. It is assumed that the Hy-Rib is continuous over at least three spans (i.e. over four horizontal supports). If this is not the case, refer to a designer for the increase in load on the supports.

Vertical Joints in Thin Walls : Hy-Rib placed vertically continued

Note that the distance stated in **Table D** for the support centres at any given level in the pour, should not exceed the sum of the support thickness and the clear span distance shown at **Table C** calculated on the Hy-Rib simply supported in each span.

There may be cases where the designer, knowing the rate of rise, concrete temperature etc., would predict a LOWER maximum pressure than that from the full fluid head of concrete, i.e. a truncated pressure diagram. This is discussed in more detail on page 25 of this guide.

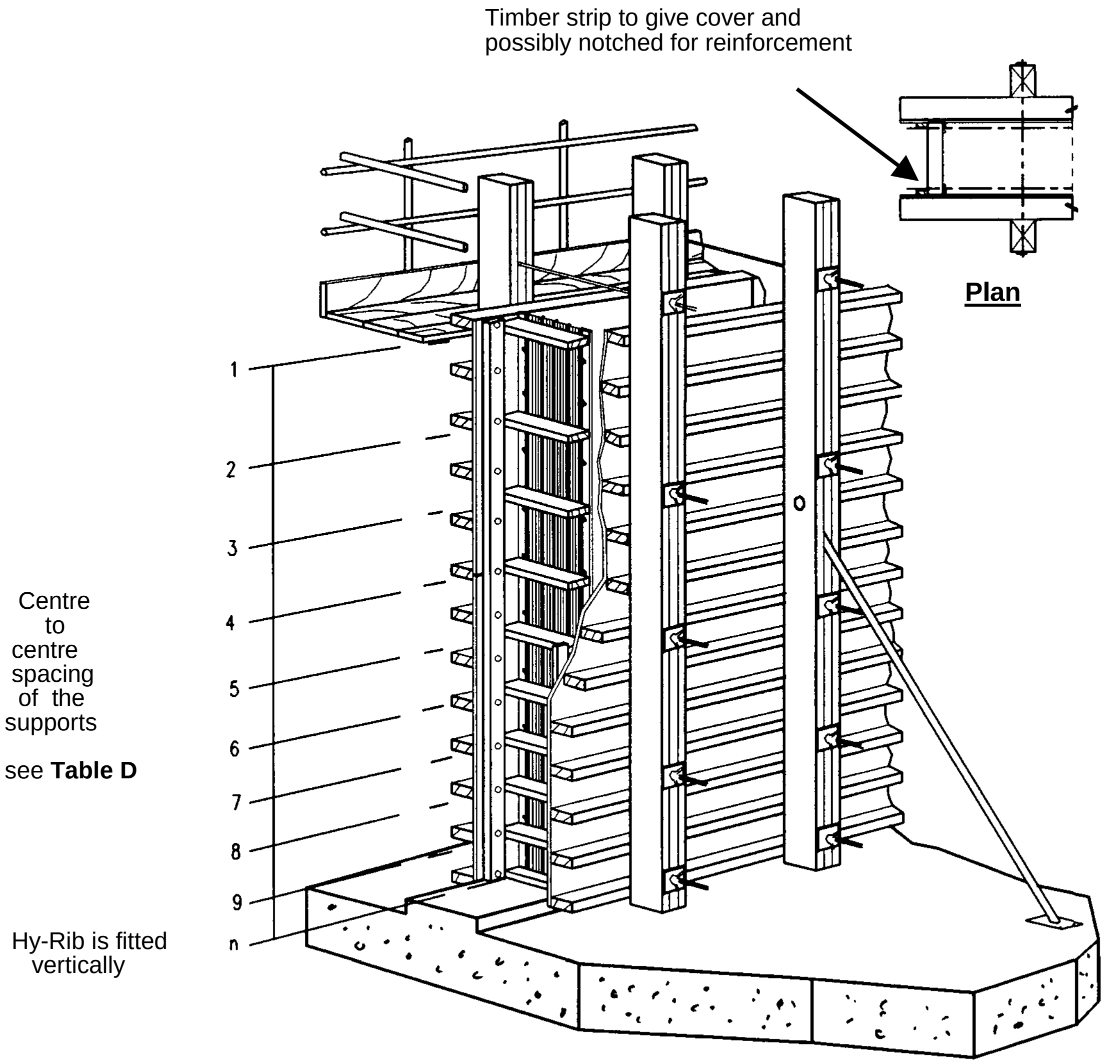


Fig. 11 Typical detail of Hy-Rib stop end to a thin wall.

Construction Joints to Walls : continued

Vertical joints in thick walls : Hy-Rib placed horizontally

Vertical construction joints in thick walls over 900mm width, will usually have the Hy-Rib fitted with the ribs horizontally, and supported by vertical timber or aluminium members.
See Figure 12. The total forces on this wide stop end will be much larger than that on narrow walls. In this orientation, the safe span of the Hy-Rib will be governed by the maximum applied Hy-Rib concrete pressure, which will occur at the bottom of the wall. The maximum clear distance between the vertical supports is determined from **Table E**. The vertical support members, timber or aluminium, the horizontal twin walings, steel or timber, and the external method of restraining the forces will all need careful design, but because the Hy-Rib concrete pressure will be less than that on conventional impermeable stop ends, the sizes of the members and the magnitudes of the forces will be reduced.

Max. concrete pressure		**Clear Hy-Rib distance between supports**		
Theoretical* Table 2 CIRIA 108	assumed for Hy-Rib	**Grade 2411**	**Grade 2611**	**Grade 2811**
kN/m²	kN/m²	mm	mm	mm
6.25	3.20	1050	850	800
12.50	6.30	750	600	575
18.75	9.50	625	500	475
25.00	12.70	525	425	400
31.25	15.80	475	375	350
37.50	19.00	425	350	325
50.00	25.30	375	300	275
62.50	31.70	350	275	250
75.00	38.00	325	250	225
100.00	38.00	325	250	225
125.00	38.00	325	250	225
150.00	38.00	325	250	225
175.00	38.00	325	250	225

Table E : Safe clear span of Hy-Rib fitted horizontally between supports for wall formwork.

NOTES to Table E.

1. The properties assume that the Hy-Rib is used with the ribs pointing into the concrete to be placed, and spanning in the strong direction between the supports with the ribs parallel with the span. See Figure 12.

2. * The theoretical pressure is that calculated using CIRIA Report 108 (Ref. 2) with a concrete density of 25 kN/m³, for EITHER a wall, a base or a column; AND applies to concrete Groups 1 to 5 inclusive.

3. It is assumed that the Hy-Rib is simply supported. Even if the Hy-Rib is spanning over several supports, its lower bending strength at the support is such that it will yield as the full pressure is applied, making critical the bending at mid-span when analysed as a simply supported member.

Vertical Joints in Thick Walls : Hy-Rib placed horizontally continued

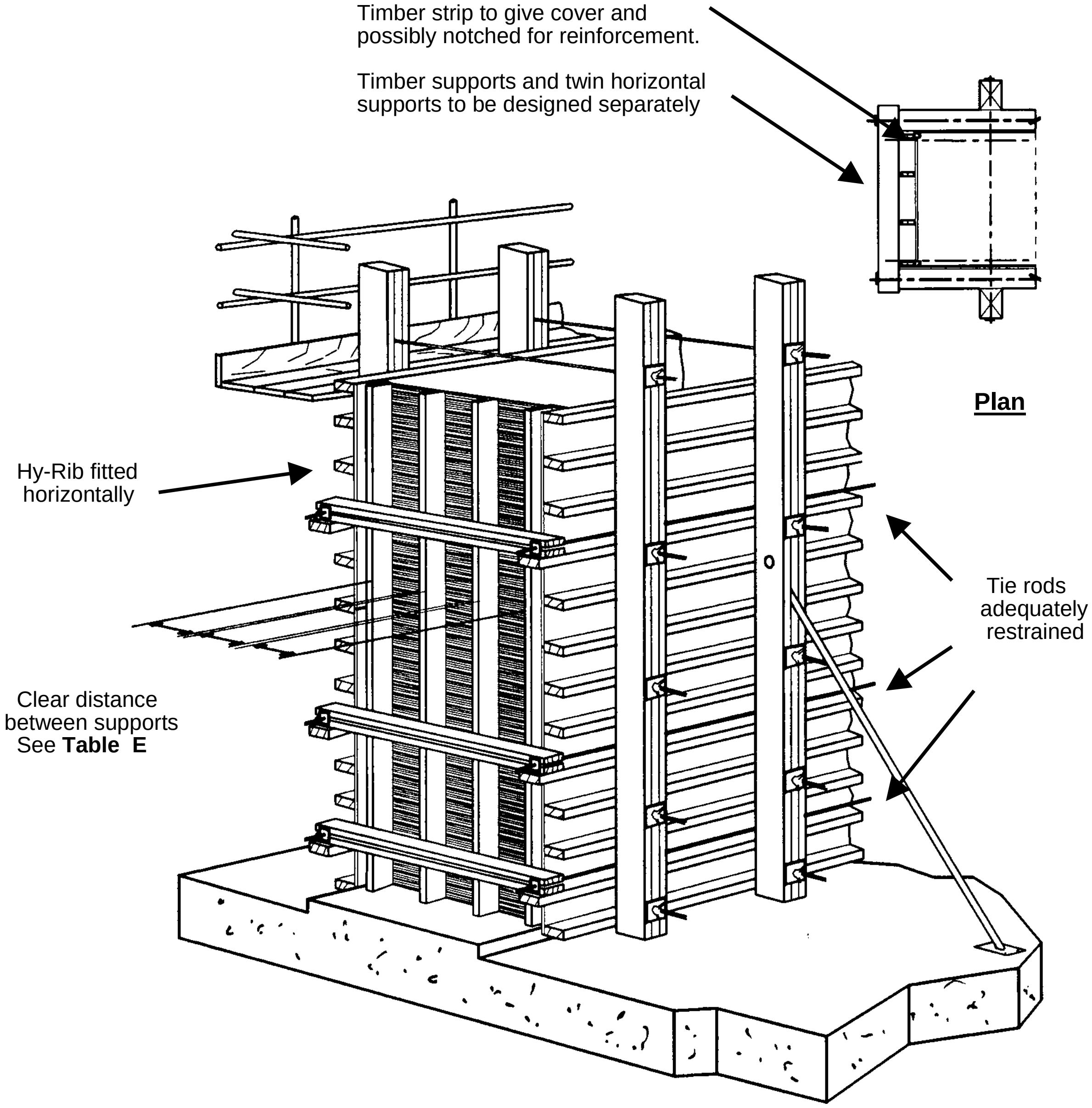


Fig. 12 Typical detail of Hy-Rib in use on the stop end to a thick wall.

Wall Formwork :

Generally when used in wall or column formwork the Hy-Rib will be wired or nailed on to a framework of formwork with the main supporting walings fitted in the horizontal direction. One of the common applications will be on single faced formwork, as shown in Figure 14. The Hy-Rib will be fitted with the ribs running vertically, and with the sheets overlapping.

(*See the section on Work on Site and the fitting details at page 7 of this guide*.)

The vertical spacing of the walings will depend on the height of wall, the design concrete pressure and the grade of Hy-Rib used. **Table D** (page 13) should be used to determine the vertical centres of the supports for a given wall. The walings, either timber, steel or aluminium (with or without timber inserts for nailing) are assumed to be at least 50mm wide.

Double faced formwork - One face in Hy-Rib

When used on double faced formwork, with Hy-Rib fitted to one face, it has the benefit of reducing the tie rod loads by reducing the design pressure. Both the BCA Trial Wall No. 2 illustrated at Figure 24, and the Taylor Woodrow Panels No. 1 to 4, all used one face in 19mm plywood and one with Hy-Rib (Ref. 3). The reduction in concrete pressure is still relevant although the drainage path for the water has increased to 500mm from 250mm (half the width) in trials No. 1, 3, 4 and 5. Tests on site (Ref. 18) on a deep stop end, see Figure 10, which was approximately 8m wide, showed that when the drainage path was increased to 4m (half the width) the full reduction in concrete pressure still applied.

Economically, one face might be required for a quality finish using a quality face material, whereas the rear formwork face could use Hy-Rib, providing significant economies of size and scale of forces.

Double faced formwork - Both faces using Hy-Rib

When used on double faced formwork, with both faces in Hy-Rib the benefit of reducing the tie rod load by reducing the design pressure has already been confirmed from the BCA Wall trials.

Whether the Hy-Rib is placed vertically, or horizontally, the same reductions in concrete design pressure are achieved, with resulting lower forces to be restrained. In practical terms this means fewer tie rods are needed; giving larger spans of supporting members and because of the lower design pressure, smaller deflections of the form face.

Curved formwork

Hy-rib is very flexible, and although a sheet material, is ideally suitable for use on curved structures, such as watercourses, swimming pool structural walls etc..

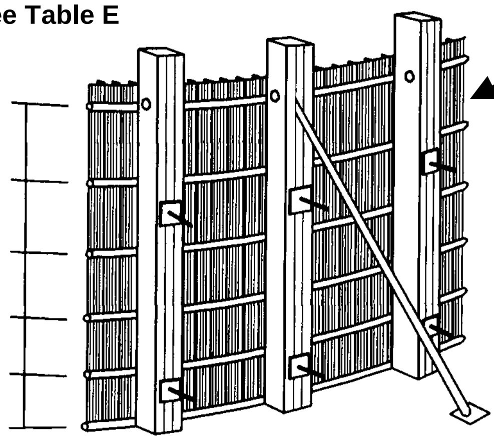
Figure 13 shows Hy-Rib placed vertically; it is easily radiussed in this direction, and can be wired to radiussed scaffold tubes or similar. The maximum vertical centres of the tubes will vary according to the concrete pressure, see **Table C** on page 11. Refer to proprietary suppliers for details of radiussed walings and items to suit this arrangement of curved Hy-Rib forms.

Clear distance between supports. **See Table E**

Radiussed scaffold tubes or similar

Clear distance between supports depends on concrete pressure.

See **Table C**



Note: The inside form faces are similar but the ribs point towards the concrete.

Fig. 13 Typical details of curved outside Hy-Rib formwork.

Single faced formwork.

Temporary works designers will be aware that single faced formwork requires extra attention to cater for the magnitude and direction of the applied and resultant forces. The use of Hy-Rib as the form face will reduce the magnitude of these forces and economise on the design, giving faster and safer construction. A typical application is shown at Figure 14.

The design for both an externally strutted single face, or a cantilevered section of vertical formwork is covered in "Formwork - a guide to good practice" (Ref. 8) at Sections 5.2.3.2 and 5.2.3.3. The magnitude of the applied forces can be halved by using the assumed Hy-Rib formwork design pressure by referring to Figure 22 at page 24 of this design guide.

The indicative centres of the horizontal walings will be those shown in **Table D** (page 14.) With single faced formwork, the critical detail to check will ALWAYS be the anchor position; in the case of a wall restrained by propping, it is the uplift that needs consideration, whereas on a cantilevered wall form it will be the actual anchor restraint. Reducing the overall force on the form face by using Hy-Rib with its reduced concrete pressure will reduce the force on these fixings.

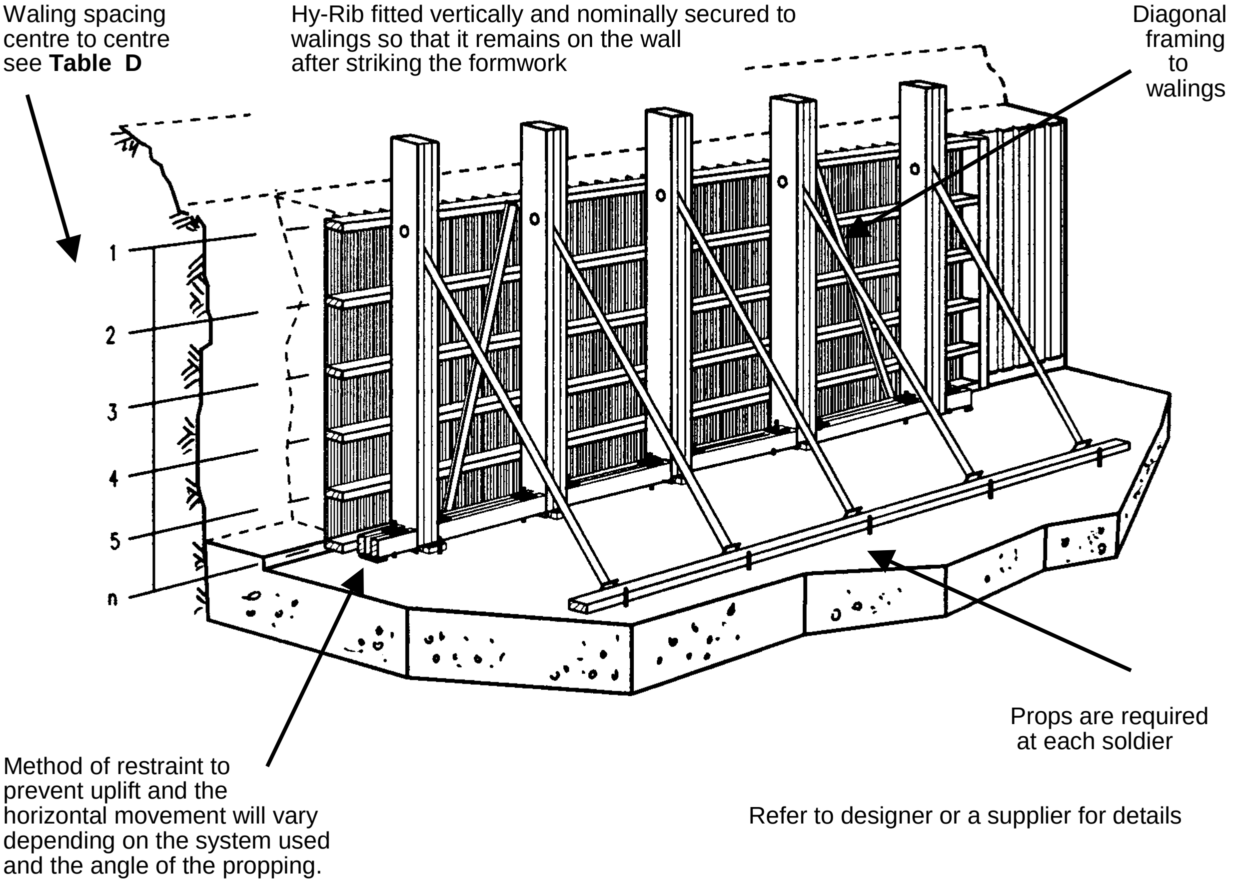


Fig. 14 Typical detail of single faced wall formwork with Hy-Rib fitted vertically

Soffit Formwork :

When used as permanent soffit formwork to a slab, the Hy-Rib has to support the wet concrete until it can support itself, such as in a suspended ground floor slab, as well as the operatives while placing and hand tamping the concrete. Where access to the underside of a slab is restricted, such as on duct covers, chamber covers or low suspended slabs the use of Hy-Rib can be the economic solution.

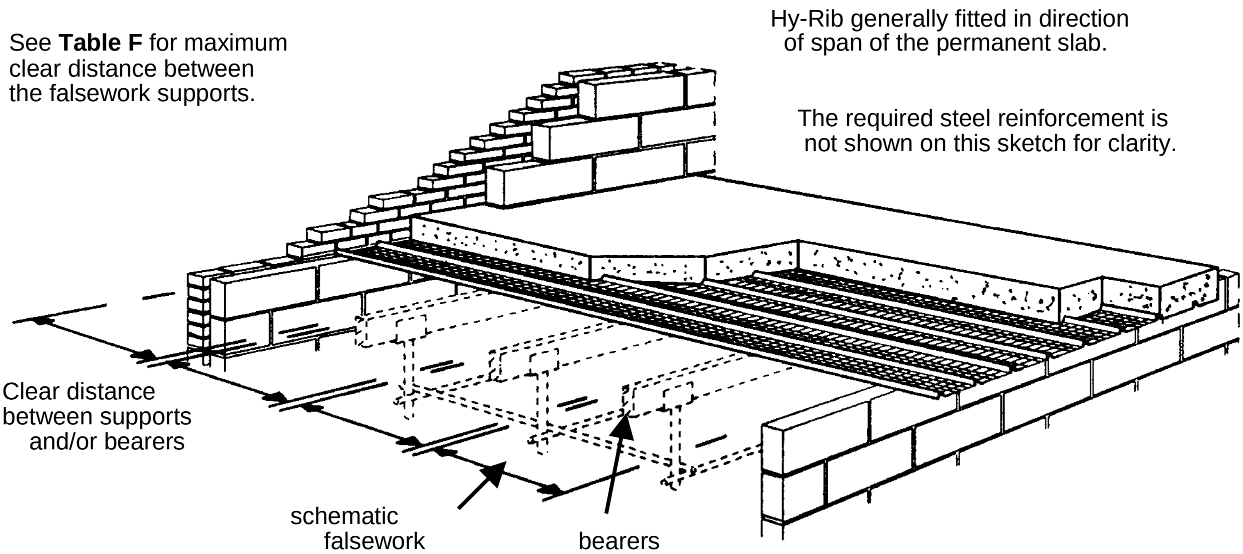
The Hy-Rib will be left in place, and in exposed applications may require additional protection for durability considerations. This aspect is outside the scope of this Hy-Rib technical guide and advice should be sought from a permanent works designer.

On all but the very short spans of a slab, the Hy-Rib will require supporting from temporary works, known as falsework. The arrangement of falsework can vary significantly, from individual adjustable steel props to complex aluminium proprietary systems; but they will all be similar in having continuous lengths of bearers to support the Hy-Rib. A typical arrangement is shown at Figure 15. The falsework bearers will generally be timber, but can be proprietary aluminium or steel beams. Further guidance is given in BS 5975 code of practice on Falsework (Ref. 17) in the CIRIA Report C558 on Permanent Formwork (Ref. 21) In all cases, the Hy-Rib is placed with the ribs spanning the falsework bearers; generally in the direction of the main slab span.

Hy-Rib as permanent formwork to slabs

The permanent works design of the slab will have been carried out to relevant standards, and is outside the scope of this guide. The Hy-Rib, during construction of the slab, has to support the full weight of the concrete, together with the additional load from the operatives placing the concrete, known as the construction operations load. (See BS 5975 on Falsework (Ref. 17)). The safe span of the Hy-Rib, i.e. the clear distance between the supports, should not exceed the value given in **Table F**. At end supports the Hy-Rib should have at least 50mm of bearing when seated on steel or concrete, increasing to 70mm on masonry (CIRIA C558 (Ref. 21)).

Although in soffit applications the deflection between the falsework supports is rarely critical, the likely maximum mid span deflection of the Hy-Rib is stated in **Table F** for information; Note that this value is the deflection of the Hy-Rib between supports during construction, and not the final deflection of the completed slab after the falsework is struck / removed.



Where more than one sheet is used, the ends should project at least 75mm past intermediate supports.

Fig. 15 Typical arrangement of Hy-Rib as permanent soffit formwork.

Soffit Formwork continued

Hy-Rib as permanent formwork to slabs - continued

Equivalent depth of the solid concrete slab	Hy-Rib clear distance between supporting falsework bearers and estimated maximum midspan deflection (mm)					
	Grade 2411		Grade 2611		Grade 2811	
	Clear distance	midspan deflection	Clear distance	midspan deflection	Clear distance	midspan deflection
mm	mm	mm	mm	mm	mm	mm
75	950	5.4	800	3.8	725	3.5
100	875	5.2	725	3.6	650	3.3
125	825	4.8	675	3.3	600	3.1
150	775	4.5	625	3.1	575	2.9
175	725	4.2	600	2.9	550	2.6
200	700	3.9	575	2.7	525	2.5
250	625	3.4	525	2.4	475	2.2
300	575	3.1	475	2.1	425	1.9
400	500	2.5	425	1.7	375	1.6
500	450	2.1	375	1.5	350	1.3

Table F : Indicative clear distance between supports for Hy-Rib used as permanent soffit formwork

NOTES to Table F.

1. The Hy-Rib is used in horizontal direction with the ribs pointing upwards and spanning in the strong direction between supports as indicated in Figure 15.
2. In considering the permissible span of the Hy-Rib, the following loads have been included in the design:-
   the Hy-Rib self weight,
   the equivalent weight of the solid concrete slab assuming a density of 25 kN/m³,
   plus a construction operations load equivalent to Service Class 2 of 1.5 kN/m².
3. It is assumed that the Hy-Rib is simply supported. Even if the Hy-Rib is spanning over several of the falsework supports, its lower bending strength at the support is such that it will yield as the full pressure is applied, making critical the bending at mid-span as a simply supported member.
4. The anticipated midspan deflection of the Hy-Rib has been conservatively estimated using the self weight and the equivalent weight of solid concrete as simply supported; in practice the deflection is reduced by continuity.
5. Where more than one Hy-Rib sheet is used to make up a span, there should be at least 75mm projecting past in both directions at the intermediate support with the lap.
6. The minimum bearing of the Hy-Rib at end supports is 50mm for steel or concrete, increasing to 70mm when seated on masonry.

Special Applications

Joints in water retaining structures

Hy-Rib is also used to form the construction joints in water retaining structures. It can be used either with or without waterstops. As with all construction joints, good workmanship and supervision are essential. The Hy-Rib will be given the same cover as the reinforcement, and can therefore be used on water structures, such as treatment plants, tanks etc.. The application of Hy-Rib in water retaining structures is no different to that for other structures.

Hy-Rib can also be used with hydrophilic and bentonite type water stops. It is recommended that wherever the waterstop is to be positioned, a timber or plastic strip corresponding to the width of the product is fixed between adjacent sheets of Hy-Rib prior to the first concrete pour. See Figure 16 (a). After the first pour, remove the timber or plastic strip and fix the waterstop to the flat surface as per the manufacturers instructions, indicated at Figure 16 (b).

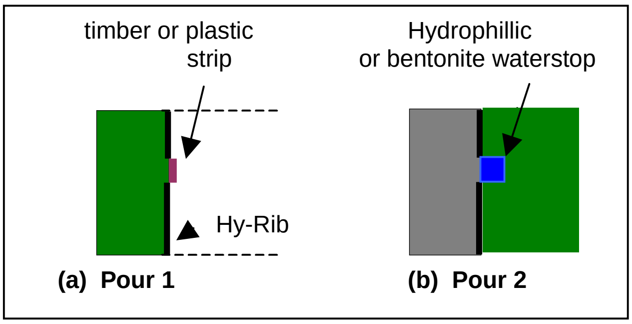


Fig. 16 Sketch of Hy-Rib at hydrophilic waterstop joint

It was previously thought that the open meshed structure of Hy-Rib would cause concern at central type waterstops, such as shown at Figures 7(b) and 8(b). Research in November 1993 at Imperial College (Ref. 5) confirmed that the open nature significantly reduced the trapping of air and risk of honeycombing under the flat section of the waterstop. The report states "compaction of concrete immediately beneath the waterstop is better using Hy-Rib compared to a solid face such as provided by plywood".

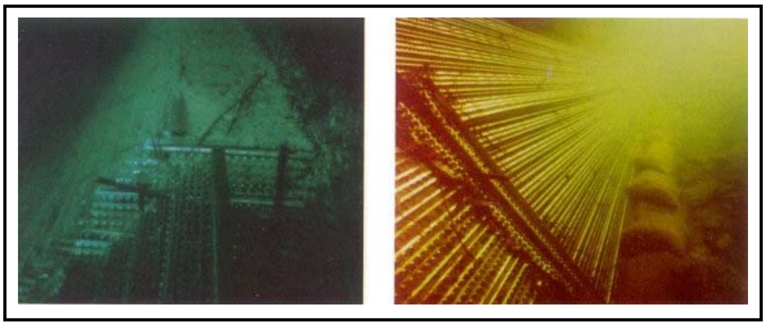
The code "Design of concrete structures for retaining aqueous liquids", BS 8007 (Ref. 6), accepts that it is not necessary to incorporate waterstops in properly constructed construction joints.

Application of Hy-Rib in underwater formwork

An interesting use of Hy-Rib is in underwater formwork, and particularly that fixed and used by divers in "limited vision" conditions. It has particularly good properties when left in place and is likely to help to reduce scour and erosion. Unlike timber and plywood, Hy-Rib doesn't float, is easy to fix and can be wired to reinforcement, steel work and other supports. A typical application is shown at Figure 17.

Once concreted, it doesn't need striking, and its surface is ideal for keying on other pours, without the necessity to employ expensive diving time to expose the aggregate and prepare the joints for subsequent pours.

Hy-Rib can also be used in the repair and protection of road and rail bridge piers that are founded in rivers and estuaries. It has shown itself to be a very innovative, yet inexpensive material for protection work, reducing labour content and giving satisfactory containment to the protection concrete.



(Kirkwall Harbour
Client: Orkney District Council
Contractor: Mowlem Northern CE)

Fig. 17 Underwater Application of Hy-Rib Formwork

Application of Hy-Rib in bearing-less bridges

Hy-Rib allows permanent works designers to detail portal structures as bearing-less bridges and ensure ease of buildability for the abutment walls without overhanging reinforcement.

The Hy-Rib solution, shown at Figure 18, allows the abutment walls to be cast, with the visible, possibly featured, inside face of wall to its full height, and cast about 20mm into the future slab. A deep vertical recess/stop end is positioned in the top of the abutments on the outer side, formed using Hy-Rib spanning horizontally. This is for subsequent fixing of the large "L" reinforcement bars for the slab pour. A typical arrangement is shown at Figure 19.

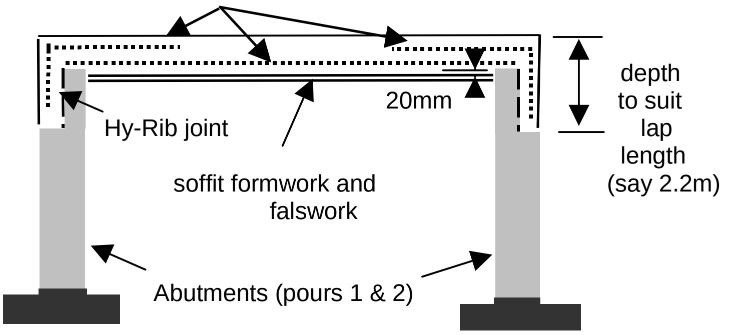


Fig. 18 Use of Hy-Rib in bearing less bridges

The maximum clear distance between the vertical supports is determined from **Table E.** Use of Hy-Rib horizontally allows the shear loop reinforcement to be fitted and placed through the Hy-Rib deep stop end. The top of the outer formwork face is deliberately left un-covered by the face material. This ensures that the Hy-Rib is visible during casting, and internal vibrators can be used down the inside of the wall with access from the open underside of the deep stop end.

Once the abutments are cast and the formwork struck, further preparatory work at the joint is almost completely eliminated, as the Hy-Rib is left in place. Construction of the deck slab as pour (3) continues, with the long "L" continuity reinforcement being easily fitted around the top corner. The Hy-Rib is left in place, and requires minimum preparation before pour (3).
The strength of such a joint in shear was confirmed in tests. (Ref. 19)

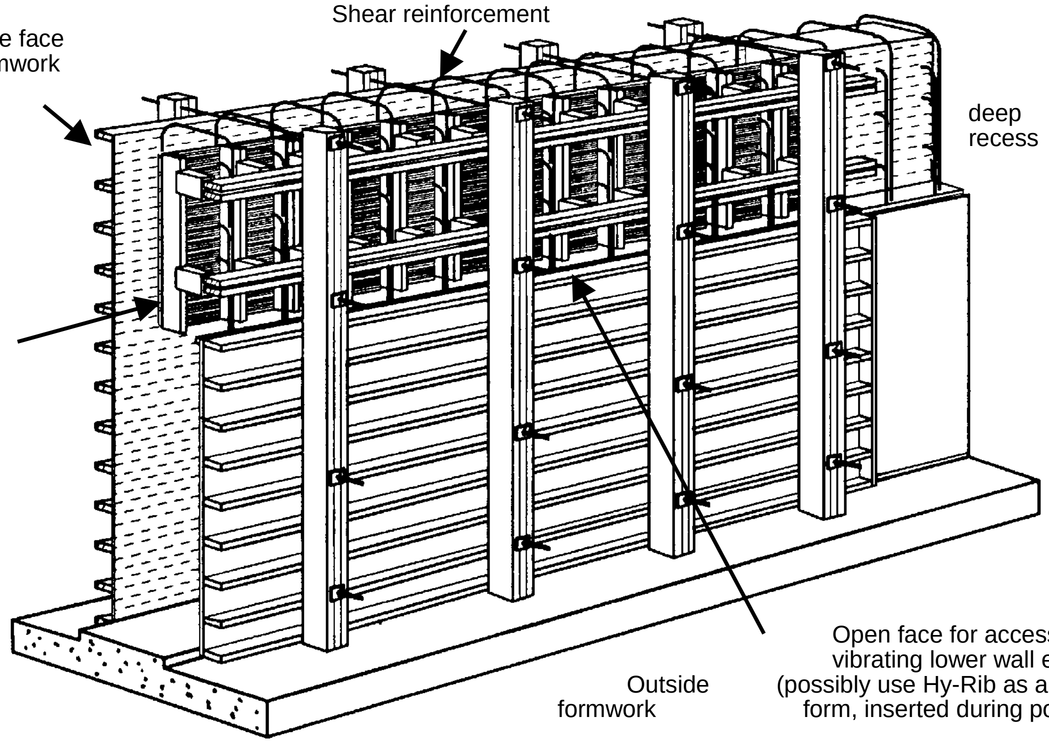


Fig. 19 Typical arrangement of a deep stop end to top of abutment wall

The acceptance in the UK by the Highways Agency of the use of proprietary steel open mesh permanent formwork, i.e. Hy-Rib, in construction joints (Ref. 22), gives the permanent works designer an opportunity to detail these bearing-less structures with more confidence.

Applications of Hy-Rib with sprayed concrete

Hy-Rib is used with sprayed concrete including applications which are fixed (wire tied) to precurved mesh fabric as the framework and as background formwork. Typical examples include shell structures, see Figures 20 and 21, and as temporary linings in tunnel construction.

Various thicknesses of concrete can be applied to the Hy-Rib with very little deformation. The recommended maximum depth of sprayed concrete is 200mm.

On sprayed shell structures, to keep concrete and grout loss to a minimum, plastic sheeting or similar can be placed behind the Hy-Rib. Once concreting is complete the backing sheet can be removed. An example is shown at Figure 20 where the plastic sheet can be seen behind the Hy-Rib.

Fig. 20 Sprayed concrete to shell structure

(a) Hy-Rib being fixed

(b) Finished concrete shell

Figure 21 Application of sprayed concrete to shell using Hy-Rib

Reduction in the pressure of concrete on Hy-Rib

The recommended reduction in design concrete pressure when using Hy-Rib, compared to the calculated Construction Industry Research and Information Association (CIRIA) Report 108 (Ref. 2) values for casting against impermeable formwork are shown at Figure 22. These show that the maximum concrete pressure obtained when using Hy-Rib is almost halved for pours up to 3m in height, with an upper limit of 38 kN/m² for walls from 3m up to 5m in height.

The research work, carried out by the British Cement Association (BCA) (Ref. 3) and Taywood Engineering (TWE) (Ref. 19), confirmed the significant reduction in the pressure of concrete placed in vertical sections against Hy-Rib when compared to the predicted pressure obtained using the full weight density head of concrete. The results from the BCA trials, referred to as "walls", each 5m high, are summarised at **Table G**. The TWE trials, referred to as "panels" were 2.225m high and their results are summarised at **Table H**. The results were published in Concrete magazine (Refs. 16 and 20).

The trials were carried out using concrete containing between 40% and 60% ggbs (CEM IIIA), with admixtures to provide a very high workability mix, some giving "significant bleeding", to give extremely fast rates of rise. The CIRIA Report 108 "Concrete pressures on formwork" (Ref. 2) categorises these concretes as Group 4, and predicts that at such rates of rise the design maximum pressure should use the weight density head of concrete. The actual concrete density averaged 23.15 kN/m³ in the wall trials.

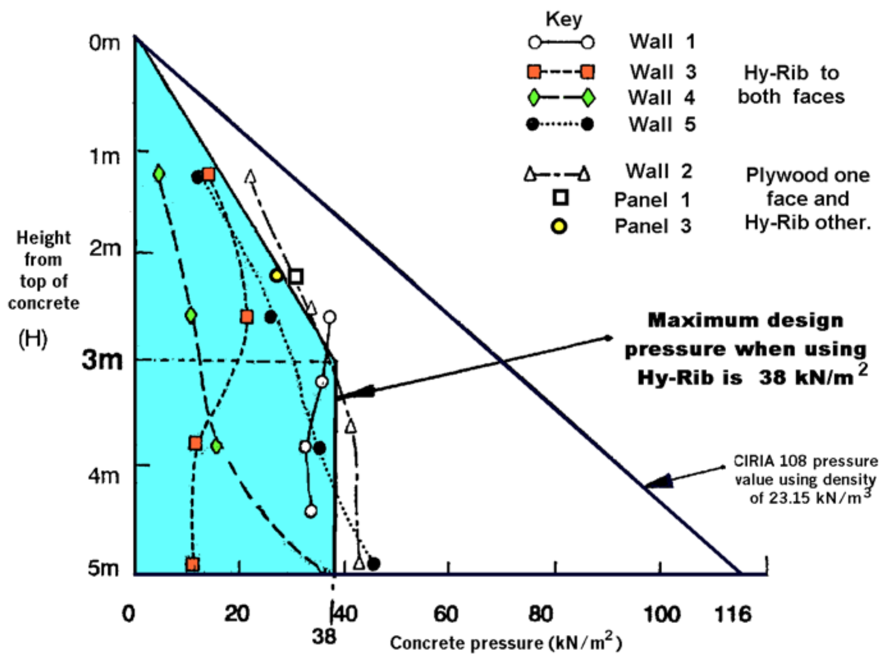


Fig. 22 Concrete pressure diagram using Hy-Rib and group 1,2,3, 4 or 5 concrete.

The industry method of determining the design concrete pressure uses Table 2 from CIRIA Report 108 with a weight density of 25 kN/m³, and concrete classified into five groups.

Although the 5m high trial wall tests were carried out on a very fluid group 4 concrete, the BCA are of the opinion that it is reasonable to assume that the pressure reductions can also be applied when using Hy-Rib with the stiffer group 1 and 2 concretes using CEM I, CEM I/R or + SR with or without any admixture. Hy-Rib is also effective when used with Group 6 and 7 concrete, and has been used with self compacting concrete (See Fig. 6). The TWE trial panels (Ref. 19) concluded that the pressure reductions were also significant with high bleed concrete CEM III B and CEM IVB.

On a very thick section (8m wide) using Hy-Rib to both faces the BCA recorded the same reduction in concrete pressure (Ref. 18).

The assumed concrete pressure diagram

Tables B, C and D for the use of Hy-Rib in slab joints, stop ends and wall formwork have been calculated assuming that the maximum pressure of concrete will occur 3m from the top of the pour - with magnitude of 38 kN/m² against Hy-Rib, but 75 kN/m² against impermeable formwork. The reduction is in the ratio 38/75 = 0.506. This is shown at Figure 23(a).

The shape of the assumed concrete pressure diagram on a stop end to a slab of depth d, which is less than 3m in height, i.e. using Table B, is shown diagrammatically at Figure 23(b).

In certain cases, particularly where the rate of rise of the concrete up the face of the Hy-Rib is slow, the full weight density concrete pressure may not be developed. Temporary works designer's will be aware of this truncated shape of the concrete pressure diagram when using Table 2 from CIRIA Report 108 (Ref. 2). The type of concrete mix, rate of rise, concrete temperature etc., are also factors that can affect the maximum pressure. The assumed shape of the pressure diagram at the very bottom of such a pour is uniform and NOT triangular, see Figure 23(c) and 23(d). The maximum safe clear distance between the Hy-Rib supports is now limited to the clear distance using Tables C, D or E for a uniform concrete pressure. Note that because the applied pressure is now considered uniform, it does not matter whether the Hy-Rib is placed vertically or horizontally.

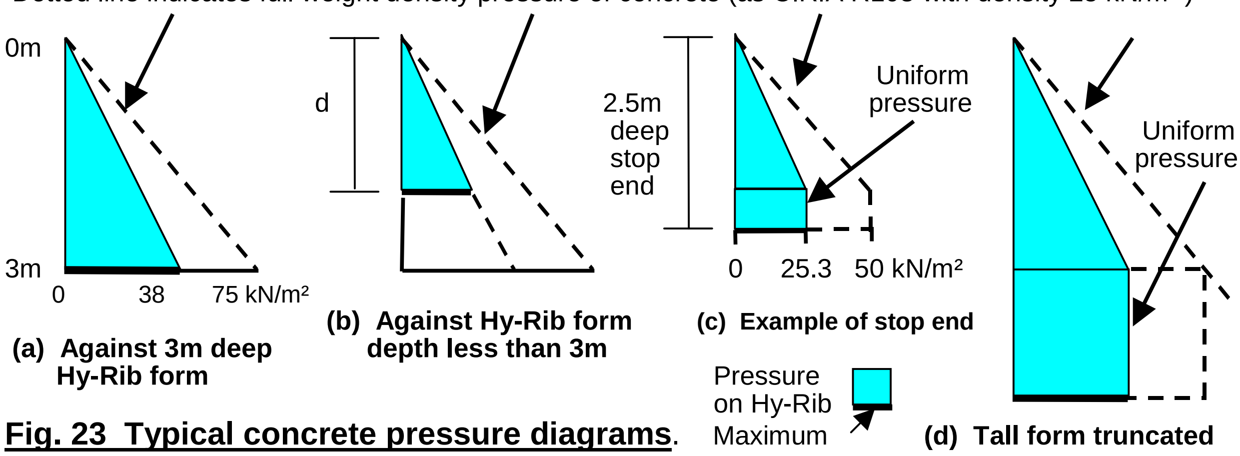
EXAMPLE of a 2.5m deep stop end shown at Figure 23(c) - Hy-Rib placed horizontally.

> *Consider a 2.5m deep stop end using Hy-Rib Grade 2411 placed horizontally between supports. The concrete contains up to 40% pfa and is Group 4. If the known rate of rise of the concrete up the Hy-Rib face was 2 m/hour and the concrete temperature was 15ºC, then from CIRIA Report 108 Table 2 the theoretical maximum concrete pressure would be* P_{max} ***= 50 kN/m²**.*
> *Referring to the diagram at Fig 23(c), the bottom Hy-Rib sheets will be spanning horizontally with a Hy-Rib uniform pressure, reduced by the factor 0.506 (mentioned at top of this page) giving 50 x 0.506 = 25.30 kN/m². Hence from* ***Table C*** *the safe clear distance between supports for this stop end with 2411is 375mm.*
>
> *It is important to note that if you had inadvertently referred to* ***Table B*** *for the clear distance, it states 450mm clear between the supports for grade 2411. This would overload the bottom Hy-Rib sheet as the assumption in Table B is that the pressure diagram is triangular in shape, as Figure 23(b), and not truncated as Figure 23(c).*

Similar calculations are possible on ALL wall formwork, but the limiting value is still the maximum safe span of the Hy-Rib for the design concrete pressure using either **Table C, D or E**. An example of the truncated shape of the pressure diagram is shown at Figure 23(d).

Note that designers may also wish to increase the spacings shown at **Tables D and E**, but because the concrete pressure is always zero at the top, the benefits will only occur towards the bottom of the pour. The safe distance between the supports is limited to the clear distance from **Table C** for the uniform concrete pressure, plus the thickness of the supports. In such cases a more rigorous analysis may be justified incorporating the structural properties of Hy-Rib listed at **Table A** on page 5.

Dotted line indicates full weight density pressure of concrete (as CIRIA R108 with density 25 kN/m³)



(a) Against 3m deep Hy-Rib form

(b) Against Hy-Rib form depth less than 3m

(c) Example of stop end

(d) Tall form truncated

Fig. 23 Typical concrete pressure diagrams.

British Cement Association test results

A summary of the full scale wall trials carried out at Wexham Springs by the BCA (Ref.3) is shown in **Table G**. The arrangement of one of the wall trials is shown in Figure 24.

Details	units	Trials all 5m high, 2m long & 500mm thick				
		Wall One	**Wall Two**	**Wall Three**	**Wall Four**	**Wall Five**
Formwork face(s)	front	**Grade 2411**	**Grade 2411**	**Grade 2411**	**Grade 2811**	**Grade 2411**
	rear	**2611**	**plywood**	**2611**	**2811**	**2411**
Orientation of the Hy-Rib		ribs horiz.	ribs vert.	ribs vert.	ribs vert.	ribs vert.
Centres of supports	mm	350/400	600	600	600	600
Clear span between supports	mm	275 and 325	448	448	448	448
Cement		OPC	OPC	OPC	OPC	OPC
Admixture (Cormix)		P4	P10	P10	P10	P10
Additions		40% ggbs	40% ggbs	40% ggbs	40% ggbs	40% ggbs
Concrete temp. (average)	ºC	12.8	8.6	10.1	16.9	19.4
Average slump	mm	130	80	70	70	60
Time to pour 5m	mins	14	8	7	8	9
Rate of Rise (R)	m/hr	21	38	43	38	33
Concrete Density (Approximate)	kN/m^3	23.3	23.2	23.0	23.2	23.1
Theoretical design concrete pressure	kN/m^2	116	116	115	116	115
Maximum concrete pressure (estimated from load cells)	**kN/m^2**	**36**	**44**	**22**	**35**	**45**

Table G : Summary of results from BCA wall trials

Fig. 24 View of BCA Hy-Rib 5m Wall Trials

Pressure Conversion

For concrete in Groups 1 to 5, to convert the CIRIA design pressure into the applied concrete pressure on the Hy-Rib face :-

For P_{max} 0 to 75 kN/m^2

multiply by ratio 38/75 = 0.506

P_{max} x 0.506 = Hy-Rib pressure

For P_{max} greater than 75 kN/m^2

use P_{max} = 38 kN/m^2

Taywood Engineering Ltd test results

A summary of the full size panel trials (Ref. 19) is shown at Table H. They were carried out, using blended cements with 40% ground granulated blast furnace slag (ggbs) and 60% ggbs mixes, and with vibration as recommended and with excessive over vibration. The concrete was examined for voids by coring, see page 28. The pressure of the concrete was recorded.

The trials concluded that Hy-Rib permanent formwork works satisfactorily on concrete containing 40% and 60% ggbs cement replacement, both against the Hy-Rib face, and for the subsequent concrete cast against the joint. Figure 25 shows two of the panels.

	Units	Test Panels 2.225m high and approx. 1.95m long				
		Panel One	**Panel Two**	**Panel Four**	**Panel Three**	**Panel Five Note (i)**
Formwork face(s)	front rear	**2611** plywood	**2611** plywood	**2611** plywood	**2611** plywood	plywood Panel 3
Orientation of Hy-Rib	-	ribs horizontal		ribs horizontal		n/a
Centres of Hy-Rib support	mm	475	475	475	475	n/a
Clear Span of Hy-Rib	mm	400	400	400	400	n/a
Width of wall	mm	500	500	500	500	450
C35 concrete with PC 42.5 and cement replacement		40% ggbs		60% ggbs		
Initial slump at placing	mm	150	95	165	175	220
Bleed (%)	%	1.59	0.80	1.07	1.61	
Concrete temperature at placing (average)	°C	15.5	17.0	9.3	9.3	
Concrete density	kN/m³	23.2	23.1	23.1	23.0	23.1
28 day compressive strength	N/mm²	62.7	64.5	64.2	62.5	65
Core compressive strength at wall centre (see Note ii)	N/mm²	-	-	62.3	55.8	-
Hy-Rib face (see Note ii)	N/mm²	-	-	66.7	62.0	-
Adherence to vibration: A: Hy-Rib recommendations		♦			♦	♦
B: Held close to Hy-Rib face			♦	♦		
Theoretical Pressure P_{max}	kN/m²	51.6	51.4	51.4	51.2	-
Maximum concrete pressure	kN/m²	**35.8**	**25.9**	**35.8**	**32.9**	-

Table H : Summary of results from TWE panel trials

Fig. 25 View of TWE Panel 3 and 4

Notes to Table H

(i) Panel 5 used pigmented concrete and was cast up against the Hy-Rib face of Panel 3.
(ii) Mean of three core results stated.

The trials also evaluated what happens to the concrete if the recommended vibration techniques stated at page 23 are not adhered to; Panels 2 and 4 were vibrated for longer periods with the vibrator held close, only 150mm, from the face.

Cores were taken through most panels and examined. See page 28.

Performance and quality of concrete at joints formed with Hy-Rib

To verify the performance of Hy-Rib at construction joints, several tests (Refs. 4, 5, and 19) have been carried out under research conditions, including the investigation of cores taken through the Hy-Rib at the joint. (Refs. 19 and 20). The evidence suggested that if there are differences, these favour the use of Hy-Rib permanent formwork

The TWE panel trials used particularly fluid mixes. During concreting, extensive bleeding of water through the Hy-Rib was observed, particularly noticeable when the concrete was being vibrated. This seepage continued for at least 30 minutes AFTER completion of concrete placement and vibration. Subsequent detailed examination concluded that there was NO detrimental effect on the concrete quality near to the Hy-Rib face due to the bleed. Coring of several Panels further established that, if anything, the concrete properties had been enhanced in the Hy-Rib joint area.

Examination of cores

In the TWE panel tests, 100mm diameter cores were taken. All the concrete was observed to be well compacted with NO evidence of continuous voidage, in fact the ends of cores cast against plywood noticeably contained less coarse aggregate. Cores were also taken through Panels 3 and 5; two across the scabbled joint where Hy-Rib had been removed, two at Hy-Rib positions and a further two, deliberately at laps of Hy-Rib sheets.

Fig 26 View of core at Hy-Rib lap position Panel 3 / 5

Examination at the ribs of the horizontally fitted Hy-Rib showed no cavities present. Figure 26 shows the core at the lap position of the Hy-Rib. TWE concluded that there was no problem with compaction at any position on the Hy-Rib.

Item	Location	Shear tests		Flexure tests	
		Average shear stress on area 0.09m²	unity factor	Average point load P	unity factor
Plain scabbled	Panel 3 / 5	0.80 N/mm²	1.00	4.38 kN	1.00
Hy-Rib	Panel 3 / 5	1.22 N/mm²	1.52	5.17 kN	1.18
Lapped Hy-Rib	Panel 3 / 5	not tested		5.30 kN	1.21

Table J : Summary of shear and core flexure tests from TWE panel trials

Shear and flexure tests

A method of test was developed on Panel 3 and 5 by arranging "blocks" that could be levered off using an hydraulic ram. The results (Ref. 19) are summarised at **Table J**. Such interfaces have never previously been examined in this way, and although only two of each item were tested, did show conclusively that the Hy-Rib joint was much stronger than a scabbled joint.

A useful subsequent test was carried out on the six 100mm circular cores to test bending strength (flexure) across the joints. A simple arrangement, shown in Figure 27 was used and the results are summarised in **Table J.** It was significant that the lapped Hy-Rib with its minimum two layers of meshed material at the lap performed better in flexure than a single layer of Hy-Rib.

Although it is recognised that detailed conclusions cannot be established from only two tests, the results in shear and bending confirm that the failure loads in Hy-Rib joints are at least 18% stronger than those achieved with conventionally scabbled joints.

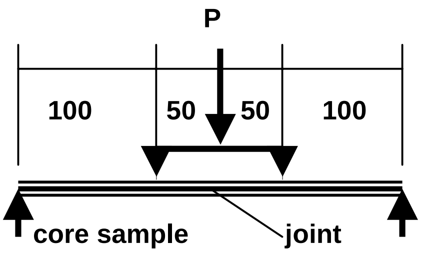


Fig. 27 Diagram of core bending test

References

1. BRITISH STANDARDS INSTITUTION, Specification for continuously hot-dip zinc coated low carbon steels, sheet and strip for cold forming: technical delivery conditions, BS EN 10142: 2000, July 2000, London, 24pp.
2. HARRISON, T.A. and CLEAR, C., Concrete pressure on formwork, Construction Industry Research and Information Association, Report 108, London, September 1985, 32pp
3. BRITISH CEMENT ASSOCIATION, Hy-Rib permanent formwork trials, Report and Appendix, RE1.031.01.1, BCA, Slough, February and July 1992, 22pp and 9pp.
4. REGAN P.E., An investigation of the shear resistance of construction joints formed by Hy-Rib, Polytechnic of Central London, April 1985, 17pp
5. PULLEN, A., Trial casting of Expamet Hy-Rib Stop-End with Waterstop, Concrete Research and Innovation Centre, Client report CRIC/93/010/001, London, November 1993, 7pp.
6. BRITISH STANDARDS INSTITUTION, Code of practice for design of concrete structures for retaining aqueous liquids, BS 8007: 1987, London, 32pp.
7. BRITISH STANDARDS INSTITUTION, Structural use of timber, BS 5268, Code of practice for permissible stress design, materials and workmanship, BS 5268:Part 2: 2001, London, 168pp.
8. CONCRETE SOCIETY, Formwork **-** a guide to good practice, Report by the Concrete Society, CS 030, Camberley, 2nd Edition, 1995, 286pp, ISBN 0946691 52 5
9. BRITISH STANDARDS INSTITUTION, Structural use of concrete, Code of practice for design and construction, BS 8110: Part 1: 1997, inc. AMD 9882 September 1998, London, 132pp.
10. BRITISH CEMENT ASSOCIATION, Concrete on site, Set of 11 booklets, Crowthorne, Publication No 45.201-211 (May be purchased individually)
(No.3 Formwork, 14pp, Ref. 45.203,) November 1993
(No.6 Curing, 8pp, Ref. 45.206) November 1993
(No.7 Construction Joints, 8pp, Ref. 45.207) November 1993.
11. THE CONCRETE SOCIETY, Curing Concrete, Digest No.3, Ref. CS.014, Concrete Society, Camberley, 1985, 8pp. ISBN 0 7210 1308 2
12. THE CONCRETE SOCIETY, Joints in In-situ Concrete, Digest No. 10, Ref. CS.053, Concrete Society, Camberley, 1988, 7pp. ISBN 0 946691 29 0
13. WILSHERE, C.J., Formwork, Thomas Telford, London, 1989, 84pp. ISBN: 0 7277 15119
14. Qi TRAINING, Good Formwork Practice, VHS Video, Qi Training, Swindon, November 1989, 35mins..
15. Qi TRAINING, Curing and protecting concrete and striking formwork, VHS Video, Qi Training, Swindon, May 1992, 25mins..
16. CAMBLE, V., Reducing Concrete Pressure with Hy-Rib, Article in Concrete, Volume 28, Number 2, March/April 1994, , Concrete Society, Camberley, pp 27 to 29.
17. BRITISH STANDARDS INSTITUTION, Code of practice for falsework, BS 5975: 1996 inc AMD 9289 December 1996, London, 134pp.
18. BRITISH CEMENT ASSOCIATION, Hy-Rib permanent formwork - Tees Barrage Project, Report SO9/1, BCA, Camberley, April 1993, 11pp.
19. CULLEN, D.A., Examination of Concrete cast against Hy-Rib Permanent Formwork, Client Report 231S/99/10705, Taywood Engineering, Technology Division, Southall, London, April 1999, 30pp.
20. PALLETT, P.F. Construction joints and stop ends with Hy-Rib and ggbs concretes, Article in Concrete, Volume 34, Number 10, November/December 2000, pages 37-40, Concrete Society, Crowthorne.
21. CONSTRUCTION INDUSTRY RESEARCH AND INFORMATION ASSOCIATION, Permanent formwork in construction, Joint Report CIRIA/Concrete Society, Report C558, London, May 2001, 174pp., ISBN 0 86017 558 8
22. HIGHWAYS AGENCY, Specifications for Highways Works, Volume 1, Structural Concrete, Clause 1710 Concrete - Construction General, Construction Joints, London, HMSO, March 1998.
23. HEALTH AND SAFETY EXECUTIVE**,** Vibration Solutions**,** Health and Safety series booklet HS(G) 170, HSE Books, Sudbury 1997, 76pp, ISBN 071 7609 54 5.

List of figures and tables

List of Figures

List of Tables

Questions, Answers and Examples

** QUESTION ** HOW DO I DETERMINE THE ACTUAL PRESSURE OF CONCRETE ON HY-RIB USED ON JOINTS, WALLS etc. ?

** ANSWER ** Using concrete in Groups 1 to 5, determine the maximum design pressure P_{max} for the formwork using Table 2 from CIRIA Report 108 (Ref.2), i.e. the theoretical maximum pressure for your temperature & rate of rise.

For values of P_{max} :-

from 0 - 75 kN/m² use PRESSURE on HY-RIB = **0.506 P_{max} kN/m²**

greater than 75 kN/m² use PRESSURE on HY-RIB = **38 kN/m²**
(For derivation of multiplier 0.506 see page 26 of this Design Guide.)

** QUESTION ** IS THE SHAPE OF THE PRESSURE DIAGRAM ALWAYS TRIANGULAR FOR HY-RIB FORMWORK USED IN JOINTS OR WALLS UP TO 3m IN HEIGHT ?

** ANSWER ** NO ; a common misunderstanding.

The SHAPE of the concrete pressure diagram for Hy-Rib will be similar to that established using Table 2 from CIRIA Report 108 (Ref.2), BUT reduced in the ratio of 0.506 for walls up to 3m. See Fig. 23(b) on page 25.

The position of the maximum pressure will still occur at the same position measured from the top of the form.

Where the full weight density head of concrete is not reached, for example on some very slow pours, the shape of the pressure diagram is truncated. See Fig. 23(c) on page 25. The 0.506 ratio reduction will still apply.

** EXAMPLE ** A wall 3m high, concrete group 2, at 10ºC with rate of rise 1.5 m/h gives P_{max} = 50 kN/m².

As pressure = height x density (25 kN/m³) it follows that the height down from the top of the pour where this occurs will be
height = pressure ÷ density = 50 ÷ 25 = 2.0m

The maximum pressure on the Hy-Rib is P_{max} = **0.506 x 50 = 25.3 kN/m²**

[This will also occur 2m from the top of the pour.]

** QUESTION ** WHAT IS THE PERMITTED RATE OF RISE OF CONCRETE AGAINST HY-RIB FORMWORK ?

** ANSWERS ** For ALL Hy-Rib stop ends and construction joints up to 3m in height and designed using **Table B**, and ALL vertical joints in thin walls with supports as **Table D,** and ALL wall formwork with the Hy-Rib placed vertically and using concrete in Groups 1 to 5, at temperatures between 5ºC and 15ºC,

THEN THE RATE OF RISE IS **NOT** RESTRICTED

NOTE: *This is because the tables have been calculated using the information obtained from the weight density head of concrete on the full depth of formwork against equivalent impermeable formwork. See Fig. 22 and page 24.*
Designers should be aware that there may be restrictions imposed for other face contact materials in use on the same formwork, such as the plywood!

** QUESTION ** HOW FAR WILL THE HY-RIB SPAN FOR A UNIFORM CONCRETE PRESSURE IN WALL FORMWORK ? **

** ANSWER ** A uniform concrete pressure on Hy-Rib will occur either when the Hy-Rib is placed horizontally, and/or where the pressure diagram is truncated towards the bottom of a tall wall. See Fig. 23.

Firstly, select your maximum design pressure for the formwork using Table 2 from CIRIA Report 108, i.e. the theoretical pressure P_{max} .

Then, read off from **Table C or E** the assumed Hy-Rib design pressure for your specific application and the actual safe clear distance.

[Note that Tables C and E are similar (pages 11 and 15).]

** EXAMPLE ** On a wall what is the safe clear distance between supports using Hy-Rib Grade 2611 placed horizontally and when the theoretical design concrete pressure P_{max} from CIRIA Table 2 is 62.5 kN/m².

From **Table E** (page 15) gives a Hy-Rib assumed concrete pressure of 31.7 kN/m² and for Grade 2611 a safe clear distance of **275mm**.

** QUESTION ** ON SLAB STOP ENDS WITH HY-RIB HORIZONTAL, CAN I INCREASE THE CENTRES OF MY SUPPORTS IF THE DESIGN PRESSURE IS LOWER ?

** ANSWER ** **Possibly,** but you need to carry out a check.

Firstly, establish the theoretical CIRIA maximum concrete pressure P_{max}, then compare the safe clear distance between supports for your overall depth of joint given at **Table B** with the value given at **Table E** on page 15 using the reduced value of the CIRIA pressure.

Use the lower value for your safe clear distance between the supports.

** EXAMPLE ** Consider a 2m deep stop end poured in the summer (i.e. at 15ºC) using Hy-Rib Grade 2411 placed horizontally between supports. The concrete contains up to 40% pfa and is Group 4. The rate of rise of the concrete up the Hy-Rib stop end is 1.0 m/hour.

From CIRIA Report 108 Table 2 the theoretical maximum concrete design pressure would be P_{max} = 40 kN/m².

The concrete pressure diagram will be similar to Fig 23(c), the bottom Hy-Rib sheets will be spanning horizontally with a uniform CIRIA pressure of 40 kN/m².

Hence from **Table E** the safe clear distance between supports for the CIRIA pressure requires interpolating between 37.5 & 50 kN/m² with safe clear distances for grade 2411 between 425 & 375mm.

By inspection the safe clear distance between supports will be **400mm**.

** QUESTION ** DOES THE PRESSURE REDUCTION APPLY TO VERY WIDE CONCRETED SECTIONS ?

** ANSWER ** **YES** : Although the original tests were conducted on 500mm wide walls, and one test used Hy-Rib on one side only, subsequent measurements by BCA (Ref. 18) recorded the same reduction in concrete pressure on a very thick section (8m wide) whilst pouring a high double faced wall using Hy-Rib to both faces. (see also Figure 10)

** QUESTION ** WHEN USING HY-RIB PLACED VERTICALLY ON WALL FORMWORK, WHAT ARE THE WALING CENTRES ? **

** ANSWER ** The indicative spacing of the walings is shown at **Table D** on page 13. The positions of the walings are numbered starting from the top of the wall. The spacings depend on the grade of Hy-Rib.

[*Note that when the Hy-Rib is placed vertically, the same Table D is used whether it is double faced, or single faced Fig. 14.]*

** EXAMPLE ** Formwork to a single faced wall is required for a deep basement pour of 3.4m height. The walings selected will be a proprietary aluminium section of 80mm width. Is there any advantage in selecting Hy-Rib grade 2411 in preference to grade 2611 ?

The vertical spacing of the walings is shown at **Table D** and also indicated at Fig. 9 for a single faced wall. Looking at the number of walings needed by reference to **Table D** shows that for a 3.4m high wall :-

using grade 2411 there are eight walings required, but to use grade 2611 requires a minimum of nine walings.

Thus, use of grade 2411 reduces by over 11% the number of walings needed.

** QUESTION ** HOW FAR WILL THE WALINGS SPAN ? **

** ANSWER ** An answer to this question requires a calculation which is outside the scope of this Hy-Rib designers guide. Refer to a designer and/or the book "Formwork - a guide to good practice" (Ref. 8).

Table D does give an indication of the likely load per metre on the waling!

** QUESTION ** CAN HY-RIB BE CURVED ?

** ANSWER ** **YES** Obviously across the ribs it has a low strength and can easily be bent, See Page 17

** QUESTION ** CAN I CONCRETE WALLS or STOP ENDS TALLER THAN FIVE METRES ?

** ANSWER ** **YES** - although the tests carried out at the BCA (Ref. 3) and reproduced at pages 24 and 26 were conducted on walls 5m high, the shape of the results clearly show that a maximum value is achieved at three metres measured from the top of the wall.

** EXAMPLE ** To date the tallest wall using Hy-Rib has been 30m high.

** QUESTION ** CAN I USE HY-RIB WITH SELF-COMPACTING CONCRETE ?

** ANSWER ** **YES** - Hy-Rib has been used on stopends up to nearly 400mm deep. (See Figure 6 on page 8)

Quick Reference

Your Hy-Rib Representative is . . . .

Contact Telephone No. is . . . .

Contact Facsimile No. is . . . .

Contact email address is enquiries@hy-rib.com

NOTES

Liability Clauses

Whilst every effort has been taken to ensure that the information provided in this temporary works designers' guide is correct and based on current good practice and experience, Expamet Building Products Ltd reserve the right to amend, modify or withdraw it without prior notice.

As Expamet Building Products Ltd are suppliers of Hy-Rib only, the responsibilities for the safe assembly, fitting and use of Hy-Rib on site and in the completed structure must remain with the customer. All bearers, timbers, falsework and supporting reinforcement shown in this guide are indicative and to be designed by others.

These liability clauses do not affect the purchaser's statutory rights under current legislation.

pfp/16/12/04