Northern Periphery Project Roundpole Construction Sub-Project

Lead Partner
Gaia Architects
With
Buro Happold, Northwoods Construction

Aim
To identify opportunities for the use of roundpole as part of a composite building element.

Summary
The review of opportunities for a composite element focussed on the potential for a concrete/roundpole precast floor unit.

The first choice for the application of the prototype was in the CSCT headquarters offices, however the postponement of this project mean that other options were then investigated.

Optimum sizes and spans were established.

A prototype was specified and engineered, then constructed and tested in Ullapool by Northwoods Construction.

Applications for the use of the prototype were developed as part of the floor of a house to be built in Glencoe, in the Northern periphery area.

Potential production methods for the element have been investigated.

Further development of the prototype is being pursued via the CRAFT research scheme, by Gaia Architects.
1. Introduction

This project investigates the benefits which may accrue from using roundpole in association with other materials in order to exploit its best structural properties and overcome its weaker ones. This research project specifically looks at the use of roundpole as a tension element in a composite floor slab. The poles are used in lieu of steelwork reinforcement and are covered with a concrete layer, which takes the compression loads while the poles restrain the panel in tension.

The objectives were:

- to brainstorm a range of opportunities for the use of roundpole in composite constructions.
- to design prototype composite elements and write appropriate specifications.
- to select an example as candidate for building and testing
- to build a prototype and test it.
- to look at opportunities for the inclusion of the prototype in a building
- to look at further opportunities for the development of the element
2. **Initial Project Development**

Various definitions of what constitutes Composite Construction were discussed, and several structural and constructional systems were proposed as possible candidates for research. It was agreed that the combination of a concrete topping with roundpole formwork / tension reinforcement to form a suspended slab was the most promising direction for research.

It was decided to apply the proposed slab element as a prototype to a live project. The new Headquarters for CSCT (The Central Scotland Countryside Trust) was at a development stage and with a willing client. The first floor of the building was selected for the application of the principle.

The conclusion from this exercise was that the optimum spans were likely to be between 4 and 6 metres and the engineering of the slab proceeded on this basis.

**Design Development**

A separate research application for further work on Composite wood and concrete / limecrete units was developed and submitted, and this placed a strong emphasis on this project having a prototype testing aspect. It was decided to focus on the key aspects of using roundpole as a sub structure. The unevenness of roundpole makes it unique in the resolution of its detailing. With this in mind, a number of key areas of investigation were discussed, and a brief 'sketch' report of these follows.

3. **Key Areas of Investigation**

- **Optimum Cut**
  
  The nature of the optimum roundpole.  Given that each stage of processing adds expense to the material it is essential to seek to use roundpoles with as little processing as is possible.

**Fig. COCE 1**

- **Timber Selection**
  
  The size of the circumference generally and the acceptable tolerances in terms of the tapering and the diameter variation.

**Fig. COCE 2**
Lateral Connection
The way of linking the material to gain most benefit structurally - does it require friction and 100% lateral connection to make the structural continuity? Is a side cut necessary to make it work?

Fig. COCE 3

Bonding
What are the essentials in bonding the materials together (a) mechanically and (b) in friction. From this will come a proposal for the most effective Span (say, a range of 2.5m to 4m) Methods of caulking the space between logs need to be looked at as a means of ensuring that the concrete does not spill out between logs. This needs to be combined with the properties of any bonding material which will ensure that the structure acts in unison.

Fig. COCE 4

Optimum Span
What are the optimum spans for a unit? It will be very informative to produce a set of Load/Span Tables for the finally selected design proposal.

Fig. COCE 5

Pilot Test of the Unit
A confirmed design proposal for CSCT provided the opportunity to construct a prototype panel and to then test it for all the usual properties normally investigated, including bending and shear testing of appropriately sized units.

Production
What is the most effective way to produce these panels? (a) in situ - cast on site? (b) with timber prefab and concrete casting? or (c) all cast under cover in a central facility? What are the cost implications?
Cost Effectiveness
There is also the need to look (a) at the cost effectiveness of the whole process as holistic design and production and (b) the acceptability of the units within the cost criteria.

Developing the Panel
To answer some of the above questions, it was agreed that the panel must be tested structurally - work which will be undertaken by Northwoods in Ullapool under the supervision of Buro Happold.

Sections 4, 5 and 6 deal largely with the former testing, while Section 7 looks at the introduction of these panels into an otherwise conventional building project.
4. Development of Spreadsheet for Optimising the Design of the Composite Panel

Spreadsheet Design
In order to investigate the viability of Roundpole and Concrete composite panels for use as suspended floor slabs, using the timber as the tension element of the panel, work has concentrated on the production of a spreadsheet. The aim of the spreadsheet is to optimise the thickness of the concrete topping and roundpole diameter for a given span and loading. It was decided that initial work should assume that the panels are propped during their construction as the unpropped construction condition is considered too onerous.

Further work has looked at the shear connection between the concrete and the roundpole. This chapter describes the development of the spreadsheet for analysing such panels, and draws conclusions as to appropriate spanning and load regimes for such a system.

Inputs to the spreadsheet include span, imposed load, concrete and timber properties, and the depth of concrete. From the given depth of concrete, the dead load can be calculated. The spreadsheet then calculates the design moment on the slab from the span and loading. The pole diameter is iterated until the moment capacity of the slab equals the design moment.

We should be looking for the minimum concrete depth, based on thinnings of 70 - 150mm in diameter, that allows us to use poles of less than 150mm in diameter for the tension element of the panel.

Spreadsheet Output

<table>
<thead>
<tr>
<th>Concrete depth (mm)</th>
<th>Span</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3m</td>
</tr>
<tr>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>150</td>
<td>45</td>
</tr>
<tr>
<td>200</td>
<td>45</td>
</tr>
<tr>
<td>250</td>
<td></td>
</tr>
</tbody>
</table>

Table COCE 1 - Pole diameter (mm) required for varying spans and concrete depths and an imposed load of 2.5kN/m²

Table COCE 1 shows the required pole diameter for panels with varying spans and concrete depth. The table suggests that it is possible to use roundwood thinnings for panels spanning up to 5m.

The spreadsheet also calculates deflections. The deflection due to dead load is doubled to allow for creep. This assumption should be checked if and when panels are built and tested. The spreadsheet calculates the deflection due to imposed load using an $E$ for concrete of 27000N/mm² and a deflection due to dead load using an $E$ of 10000N/mm². It then checks the total deflection against a criteria of span/360. The spreadsheet demonstrates that this criteria is satisfied for all 3 and 4m spanning panels, but panels spanning 5m require at least 200mm of concrete topping.

Discussion
Increasing the depth of concrete reduces the required diameter of roundpole. Despite the reduction in pole diameter the overall depth of the slab increases. However, this is unlikely to be of concern.

Small concrete depths mean a small dead load and therefore can be perceived to be an advantage. However there can be doubt as to whether these panels are acting compositely. 100mm of topping was identified as a sensible minimum depth.
Shear-Connection between Timber and Steel
Suggested methods of shear connection between the timber and the steel include using coachscrews, notches and the natural roughness of the timber. Investigation into the 4m spanning panel with a 100mm concrete topping shows that coachscrews with an approximate capacity of 3kN would need to be placed at 650mm centres in each log to ensure adequate shear connection. Alternatively, shear connectors could be placed at 330mm centres in every other log.

The spreadsheet also investigates partial shear connection if this is required. Insufficient shear capacity reduces the moment capacity of the slab. This will be fine if the moment capacity is still greater than the design moment on the slab. Partial shear connection has not been fully investigated although it has been included on the spreadsheet.

Conclusions
To date, work has concentrated on designing the spreadsheet and then using it to design a range of panels. It has shown that composite panels which use timber as the tension member are structurally viable. The panels would be able to use roundwood thinnings. Shear connection between the concrete and timber is possible using coachscrews.

Further Work
Further work could include the following:

Investigation into the buildability of the panels; how will they be cast and supported; how will the shear connectors be placed quickly and accurately?

Investigation into panels with poles in both directions.

Investigation into alternative forms of shear connection.

Design of a testing specification for the panels.
5. Testing Schedule for the Composite Panel

Work by Buro Happold focussed on producing a spreadsheet that would aid the design of composite concrete and round pole panels. Inputs to the spreadsheet included panel span, imposed load and depth of concrete. The spreadsheet calculated pole diameters for these parameters and then checked the deflection of the panel. A table was produced from the spreadsheet summarising the required pole depth for spans of 3, 4 and 5m with concrete depths of 100mm up to 250mm.

These tabulated results, along with the findings of the work done on the project at CSCT, helped in deciding the dimensions of the panels to be tested. During discussions with other members of the team it was discovered that prototypes of timber panels made of two-side sawn roundpole had been constructed (the Brettstapel System), and it was decided that two-side sawn timber should be used.

It was decided that more would be learned from load testing several panels with the same dimensions but with different types of shear connection between the timber and the concrete.

The types of shear connection discussed for use are:

- coachscrews screwed into pre-drilled holes.
- screws.
- nails.
- nail plates placed between adjacent poles.
- expanded metal lath nailed to the poles.

It is proposed that 5m long panels will be constructed, but each panel will be used to test spans of 3m and 4m as well as 5m. Subsequently it was decided that shear connectors will be tested prior to building panels, and the best connection chosen.

Dimensions of Test Panel
The spreadsheet suggested that very small diameters of roundpole would be suitable for composite panels. However, it was realised that the roundpoles should be at least 80mm in diameter to allow for an edge distance of 4d for the coachscrews or other ‘shear studs’. It was decided that the round poles should be between 80mm and 130mm diameter and parallel cut on two sides to 80mm.

The concrete depth decided upon was 100mm. This depth is sufficient to even up irregular sized timbers and to provide sufficient moment capacity.

The number of shear connectors of each type will be checked using the spreadsheet. The number will be based on the 5m spanning panel. If the number seems impractically large, then that particular type of shear connector will be dismissed.

Method of Testing
5m length panels will be constructed using each of the above types of shear connectors. Initially, the panel will be supported such that its span is only 3m. The span will be then increased to 4m, and finally to 5m.

The panel will be first loaded when it is spanning 3m. It will be loaded up until it is either showing a deflection of span/360, or it has been loaded to 2.5kN/m². The panel will be loaded incrementally and the deflection recorded. A load - deflection graph can be plotted. By first loading a panel that is only spanning 3m, an idea of how the panel will behave can be formed.

The span will then be increased to 4m and the exercise repeated. Then the span will be increased to 5m. If, at the larger spans, it is obvious that an imposed load of 2.5kN/m² causes failure, then the restriction should be span/360 or an imposed load of 1.5kN/m² for example. These imposed loads need to be checked against BS6399.
After each of these three spans has been incrementally loaded, and a load-deflection graph plotted for each, then the span will be reduced to the largest span which does not deflect too much under a sensible imposed load.

For example, it may have been shown that a 3.6m span deflects 10mm under an imposed load of 2.5kN/m. This is a deflection of span/360. The panel will then be incrementally loaded at that span until failure. This test will provide information on how the panels will fail - e.g. does the timber rupture or the concrete crack - and also indicate how near to failure the slabs are at serviceability loading.

The previous work led to a proposal that some physical testing should be done on either a whole panel or part of a panel. This report discusses this next step in the COCE project.

After discussions with staff in the Structures and Materials departments at the University of Bath, it was decided that it would be most interesting and useful to build and test a full sized panel. There are few precedents on the making and testing of a roundpole-concrete composite panel, and therefore the aim of the testing was to give an idea of how such a panel performs, rather than provide the definitive solution to designing composite panels.

The panel was constructed and tested by Northwoods Construction in Ullapool.

**Design and Construction of the Panel**

The panel was initially designed using the spreadsheet developed earlier in the project. The properties of the timber were taken from BS5268. The timber was assumed to be C16 timber with a diameter of 60mm. The concrete was assumed to be C35 concrete. C35 concrete has a 5% characteristic cube strength of 35N/mm². The depth of concrete was taken to be 100mm above the top of the roundpoles.

The panel was designed for an imposed load of 2.5kN/m².

Fully composite action between the timber and concrete was assumed. The shear connection was provided by coachscrews at 180mm centres.

The design spreadsheet is included in COCE Appendix 1.

The above information was the basis for the construction of the panel. However, the design evolved to take into account the availability of materials. The timber component changed to Douglas fir with an average diameter of 150mm, sawn on two sides to a width of 85mm. A concrete topping of 110mm in the centre was added to make the panel up to a depth of 260mm. The coach screws were spaced at 200mm centres at the ends, and 300mm towards the centre of the slab.

The layout of the panel is shown on page 13.

**Test Procedure**

The tests were designed with two primary objectives:

- To determine the serviceability of the panel by loading the panel with a uniformly distributed load.
- To get an idea of the strength of the panel by performing a four-point bending test on the panel.

Further details of the test procedure are in the Testing Specification included in COCE Appendix 2. The testing was performed in Leckmelm woods and therefore not under laboratory conditions. Various alternatives for loading the panel were considered, including water tanks, anchor chains and masses. It was decided that the best solution was to hire 200 x 25kg bags of cement. The 200 bags of cement could produce a total load of 50kN. When distributed evenly over the panel this produced a distributed load of 17kN/m².
Description of the Testing
The Douglas fir was felled at the end of March, and the concrete was poured on April 26th. Testing did not take place until May 17th and 18th, and therefore the concrete had three weeks in which to cure. 100mm cubes of concrete were crush tested for 7 days and 21 days (May 3rd & May 17th) with test results of 33N/mm² and 41 N/mm² respectively.

Moisture content readings were taken of the timber on May 17th, giving results of 12% in the end grain, 17% in the sawn side in the middle of the span and 18% in the round underside of the panel.

Whilst performing the serviceability test, it was realised that the panel was capable of carrying much greater loads than it had been designed for. With the loads available it would not be possible to fail the panel. It was therefore decided to only perform the serviceability test.

The panel was loaded progressively with 200 x 25kg bags of cement, to produce a maximum load of 50kN, evenly spaced over the full 5m for the main test and concentrated into the central 4m of span for the additional test (24 bags x 8 deep + 8 bags and 20 bags x 10 deep respectively). Measurements were taken using specially pointed panel pins in contact with short sections of tape measure precise to 0.5mm.

All four corners were measured at each stage to account for the crushing effect at the supported ends (a significant effect) and these readings were used to correct the deflection readings. A pre-load test was carried out which gave some permanent crushing at the ends and a very slight twisting effect (+/- 0.25mm) in the centre of the panel. The load-removed readings were then used as the datum point for subsequent testing.

Readings were taken in the sequence 1 - A - B - C - 2 and 1' - A' - B' - C' - 2', with 1 & 2 being support points on one side and 1' & 2' being those on the other side. This arrangement is shown below.
Points for deflection readings

The main loading test from 0 to 50kN took place over a period of about 90 minutes. Moving the even loading towards the centre of the panel resulted in an additional deflection of 1mm, giving a maximum average central deflection of 9mm. When the load was removed, a deflection of 2.5mm remained in the centre of the panel.

Test Results
Table COCE 2 records the deflections measured after each increment of load on the panel. The load is recorded as a total load in kN. However, it is actually distributed over the panel. Therefore the load of 10kN is actually a distributed load of 3.3kN/m².

The Load-Deflection Curve below shows that the behaviour of the panel was elastic and the Time-Deflection curve confirms that over a 24 hour period of sustained loading, the panel does not undergo significant creep.
## COCE - Composite Construction Elements

Table COCE 2

Deflections Measured after each Increment of Load on Panel

<table>
<thead>
<tr>
<th>Increment of Load on Panel</th>
<th>Deflection (mm)</th>
<th>Deflection (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>15KN</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>15KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>40KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>40KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>60KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>60KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>20KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>20KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>30KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>30KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>50KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>50KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>70KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>70KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>10KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>10KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>40KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>40KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>60KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>60KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>80KN</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>80KN (reversed)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

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Discussion and Conclusions

The construction and testing of the 5m spanning panel confirms that a composite timber - concrete panel is a viable form of precast floor construction. Indeed, floors of timber and screed have been used for many years, but they did not take advantage of composite action between the two materials. The drawings below show two such early forms of construction.

Showing two forms of early composite floor construction

Fig. COCE 10 (from Building with Lime: A Practical Introduction, S. Holmes & M. Wingate (1997), Intermediate Technology Publications.)
The advantages of these floors was that they were vermin and fire proof, and more sound resistant than a simple joist and plank floor. The COCE panel also has these advantages. The COCE panel has a pleasant aesthetic from underneath, as can be seen in fig. COCE 11, which shows the first floor construction at the Forestry School in Lyss, Switzerland. This floor is constructed from unregularised roundpoles with a panel finish applied on top.

Another advantage of using timber compositely is that low quality timber can be used to make a high strength product. Douglas Fir - a relatively strong softwood - was used in this panel, but it would have been more appropriate to use Sitka Spruce - a lower strength but much straighter tree.

The tests have shown that the panel was able to sustain even greater loads than the 2.5kN/m it was designed for. This gives confidence to use the panel in buildings, or to reduce the size of the timbers and the number of shear connectors. An unresolved issue is the crushing of the ends of the panel.
**Appendix 1**

*Composite sandwich-laminate panel design considerations*

**Horizontal Research**

**Timber/Concrete Composite Panel Design**

This spreadsheet assumes that the slab is precast during casting. Therefore, the construction stage does not need to be accounted for.

**Input**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td></td>
</tr>
<tr>
<td>Concrete slabs</td>
<td></td>
</tr>
</tbody>
</table>

**Material: Timber**

- permissible bending stress parallel to grain (lbs/in²)
- permissible tension stress parallel to grain (lbs/in²)
- minimum permitted moisture (%)
- density of timber (lbs/cm³)

**Concrete**

- compressive strength (lbs/cm²)
- dry density (lbs/cm³)
- E long (lbs/in²)
- E short (lbs/in²)

**Loading**

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead loads</td>
<td></td>
</tr>
<tr>
<td>Live loads</td>
<td></td>
</tr>
</tbody>
</table>

**Ultimate load**

- 1.4 times design load

**Output**

**Composite Stage**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment</td>
<td></td>
</tr>
<tr>
<td>Shear</td>
<td></td>
</tr>
</tbody>
</table>

**Plywise Applied Moment Requirements**

- Diameter of fiber calculated by making the equal to the applied moment by changing diameter (see "good practice")

- Suggested diameter
- Moment calculated

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### COCE - Composite Construction Elements

<table>
<thead>
<tr>
<th>Position of Load</th>
<th>Reaction force in Concrete (kN)</th>
<th>Reaction force in Steel (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>230.6</td>
<td>32.5</td>
</tr>
</tbody>
</table>

**In contact only within concrete slab?** Yes

If so, depth of neutral axis (mm) = 15

#### Elastic Behavior

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus of Elasticity of Concrete (GPa)</td>
<td>2.03</td>
</tr>
<tr>
<td>Modulus of Elasticity of Steel (GPa)</td>
<td>200</td>
</tr>
<tr>
<td>Sectional Area of Reinforcement (mm²)</td>
<td>233179.7</td>
</tr>
<tr>
<td>Moment of Inertia of Reinforcement (mm⁴)</td>
<td>5376633.6</td>
</tr>
<tr>
<td>Tensile Stress of Reinforcement (MPa)</td>
<td>766.6</td>
</tr>
<tr>
<td>Total Area of Reinforcement (mm²)</td>
<td>1663394.6</td>
</tr>
<tr>
<td>Tensile Stress due to Reinforcement (MPa)</td>
<td>766.6</td>
</tr>
<tr>
<td>Compressive stress in concrete (MPa)</td>
<td>0.0</td>
</tr>
<tr>
<td>Ultimate Compressive stress in concrete (MPa)</td>
<td>0.0</td>
</tr>
<tr>
<td>Stress in concrete (MPa)</td>
<td>0.0</td>
</tr>
<tr>
<td>Total Stress at Ultimate Limit (MPa)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

#### Shear Connection

| Shear Force (kN) | 230.6 |
| Total shear force for steel only (kN) | 240.6 |
| Total shear force for steel and concrete (kN) | 483.3 |
| Shear capacity of shear connection (kN) | 1000 |

#### Partial shear connection

| Shear force at ultimate limit (kN) | 230.6 |
| Ultimate capacity of shear connection (kN) | 483.3 |
| Ultimate capacity of shear connection for steel only (kN) | 240.6 |
| Ultimate capacity of shear connection for concrete only (kN) | 0.0 |
| Moment capacity with partial shear connection (kN.m) | 0.0 |

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2.3 Testing specifications

The testing to be done is in accordance with BS5266 Part 2: 1989.

A copy of the relevant standard of BS5266 Part 2: 1989 is in Appendix B.

This specification includes a number of limitations and guidelines. In addition to testing the deflections, it is intended to test for deflections and roughness readings.

The deflections of the panel to be measured at 6 points along the edges of the slab. Figure 2 shows the position of these points.

Two additional measurements may be made prior to the testing; the moisture content of the slab at 30% and 70%.

Material content of concrete

Since the concrete may not be homogeneous, the measurement may not be made on the same planes for the test. The edge of the concrete should therefore be measured. An additional measurement is therefore made and recorded.

2.1 Pre-load test for the slip-splint panel

According to BS5266 a pre-load equal to the deadload should be applied to the slab, and then the slab should be removed immediately before the test. Deflections at the edges should be measured as soon as the slab has been removed, and at again after a further 24 hours. This test measurement applies to the duration of all subsequent deflection measurements.

The load of the slab is approximately 500N/m².

Only one load is to be applied in this case to a slab of 1000 x 1000 mm.

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 minutes</td>
<td>Apply a load of 500N/m² for 1 hour, then remove the load</td>
</tr>
<tr>
<td>30 minutes</td>
<td>Repeat the test for 30 minutes, ensuring the deflection is not affected</td>
</tr>
<tr>
<td>24 hours</td>
<td>Remove load, measure deflection</td>
</tr>
<tr>
<td>48 hours</td>
<td>Repeat the test</td>
</tr>
</tbody>
</table>

Note: This measurement serves as the basis for all subsequent deflection measurements in the structure.
3.7 Details of test for thin composite panel

The effect of anisotropy for these modules was investigated. The final load will be maintained for 24 hours, and deformations measured later. During this 24-hour period, three times have been targeted for making these measurements. However, they do not need to be carried out in directly the same period of time or outside the environment where it was measured. The data shown in these tables are for the final measurement taken at the end and these 01 readings taken.

<table>
<thead>
<tr>
<th>Panel</th>
<th>Details</th>
<th>Targeted environment</th>
<th>1</th>
<th>2</th>
<th>3</th>
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Gaia Architects - www.gaiagroup.org
## 2.5 Floor panel bending test for the composite panel

Figure 3 shows how the panel is to be loaded.

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Fig. COCE 12

Showing how the panel was loaded.
Construction of the Composite Panel

Work Done by, and Photos Supplied by Northwoods Construction, Ullapool

The flatted poles are clamped and drilled to receive the bolts

![Image of a person working on a wood structure.

Fig. COCE 13

Coach screws are installed at 300mm centres

![Image showing coach screws installed at 300mm centres.

Fig. COCE 14

With shuttering added, the beam is wheeled out into the yard

![Image of a beam being wheeled out into a yard.

Fig. COCE 15
Concrete is poured into the form which is then removed

Fig. COCE 16

The completed panel is moved by excavator

Fig. COCE 17

Measuring the water content of the poles

Fig. COCE 18
Setting up the `deflection meters'

Fig. COCE 19

First measurements under a light load

Fig. COCE 20

The full 5 tonnes of cement bags, taking measurements

Fig. COCE 21
7. Design Application at Glencoe

With the delay in the CSCT Headquarters building it was decided instead to apply the panel to an alternative pilot project, where the possibility of including a COCE Panel in the eventual building was better timed.

The chosen building was a house, the only two-storey building in the Glencoe development.

The drawings in figs. COCE 22 - 26 show some typical application details, along with a 1st floor panel layout and overall drawings to give context.

The method of construction was discussed with the following options considered:

- Fabricate the whole element on site - assembling the roundpole and casting the concrete in situ.
- Prefabricate the timber element offsite and pour the concrete in situ.
- Prefabricate the total slab offsite including both assembly of the roundpole element and pouring of the concrete.

The pouring of concrete insitu would have an effect on the programme since it would be impossible to walk on the newly poured floor until the slab was sufficiently cured. Pouring the slab in situ would allow service ducting or an underfloor heating system to be installed if this was appropriate (not the case at Glencoe).

The timber panels would need to be adequately braced while the concrete cured, if the concrete were to be poured on site.

Prefabrication of the elements would undoubtedly speed up the process on site. The disadvantage of a completely fabricated panel would be the requirement to seal joints between panels, and the need to be very specific in terms of timing / arrival on site. A crane would be required, and this would only be possible before the upper walls and roof were constructed. The panels, once firmly located and fixed however, would effectively brace the structure and provide an instant working platform for further works.

In terms of the details shown, a number of points are worth a mention:

- The actual details show a different form of timber / concrete connection. The drawings show a 50 x 50mm batten screwed to the poles and acting partly as a connection medium between the two, although the coach screws used are allowed to stick up as in the tested panel.

- A minimum bearing of 150mm was not possible with internal partitions of only 100mm width. This is a particular problem where two panels meet 'end to end' as in detail 6. Here the bearing is only a nominal 50mm which is unlikely to be satisfactory. This would need to be tested by the engineers and the detail adjusted accordingly.

- All details allow a 10mm expansion or movement gap around the concrete layer, filled with an appropriate filler board.

- End of pole to wall junctions, as details 2 and 4, show plywood sheathing instead of softboard to the outer face of the studwork. This is shown in relation to the notion of pouring the concrete insitu and was altered to resist the assumed outward thrust of the concrete. This would not be necessary if the whole panel was pre-fabricated. It also may be inadequate for the outward thrust and may need to be reinforced. This would have to be examined by the engineers.

Glencoe Ranger’s House - Elevations and Plans (NTS)

Fig. COCE 22

Glencoe Ranger’s House - First Floor Panel Layout and Typical Cross Section (NTS)

Fig. COCE 23

Glencoe Ranger’s House - Typical Composite Panel Connection Details 1 (NTS)

Fig. COCE 24
Glencoe Ranger’s House - Typical Composite Panel Connection Details 2  (NTS)
Fig. COCE 25

Glencoe Ranger’s House - Typical Composite Panel Connection Details 3  (NTS)
Fig. COCE 26