Keeping a stiff upper rib

Simon Poole of **Cordek** looks at the benefits of including ribbed slabs within a concrete frame design, including weight reduction, long spans, vibration control and improved thermal mass, to name just a few.

Despite these established advantages over their traditional, flat counterparts, the design vogue for ribbed floor slabs diminished almost to extinction until a recent revival from designers who appreciate the visual impact ribs have within an exposed concrete floor soffit.

So, if a ribbed floor soffit is proposed for its aesthetic appeal, how can the optimum exposed concrete finish be achieved? In most cases, this starts at design stage by considering the fundamental questions when proposing 'visual concrete', such as: from which aspect and from what distance will this feature be viewed?; what type of finish to the exposed concrete surface is expected?; does this expectation include blemishes (unavoidable) and/or defects (avoidable)?

BE PREPARED

In the case of potential defects, how can these be minimised and the possibility of remedial work to the 'as-struck surface' be prepared for? How can it be made clear to both the client and the contractor what the expectations on finish should be?

EXPECTATIONS

Without question, the acceptability of an exposed concrete finish is subjective and therefore starting with a realistic and achievable specification – that meets the seven C's principle suggested by the NBS[1]: Clear, Correct, Concise, Consistent, Complete, Comprehensive and Co-ordinated – makes sense. This will help to manage expectations consistently for all involved and avoid potential issues relating to unrealistic aspirations such as 'blemish free,' which is extremely difficult, if not impossible, to achieve.

Further considerations at design stage should be sympathetic to the challenges that will be faced during construction. For example, the ribs should be designed with tapered sides circa 4–5° (known as a draft angle), as without this feature striking of the formwork is likely to prove problematic. In addition, the introduction of a radius where there are changes in direction within the exposed surface of the rib, will help to avoid areas of concrete that are susceptible to damage.

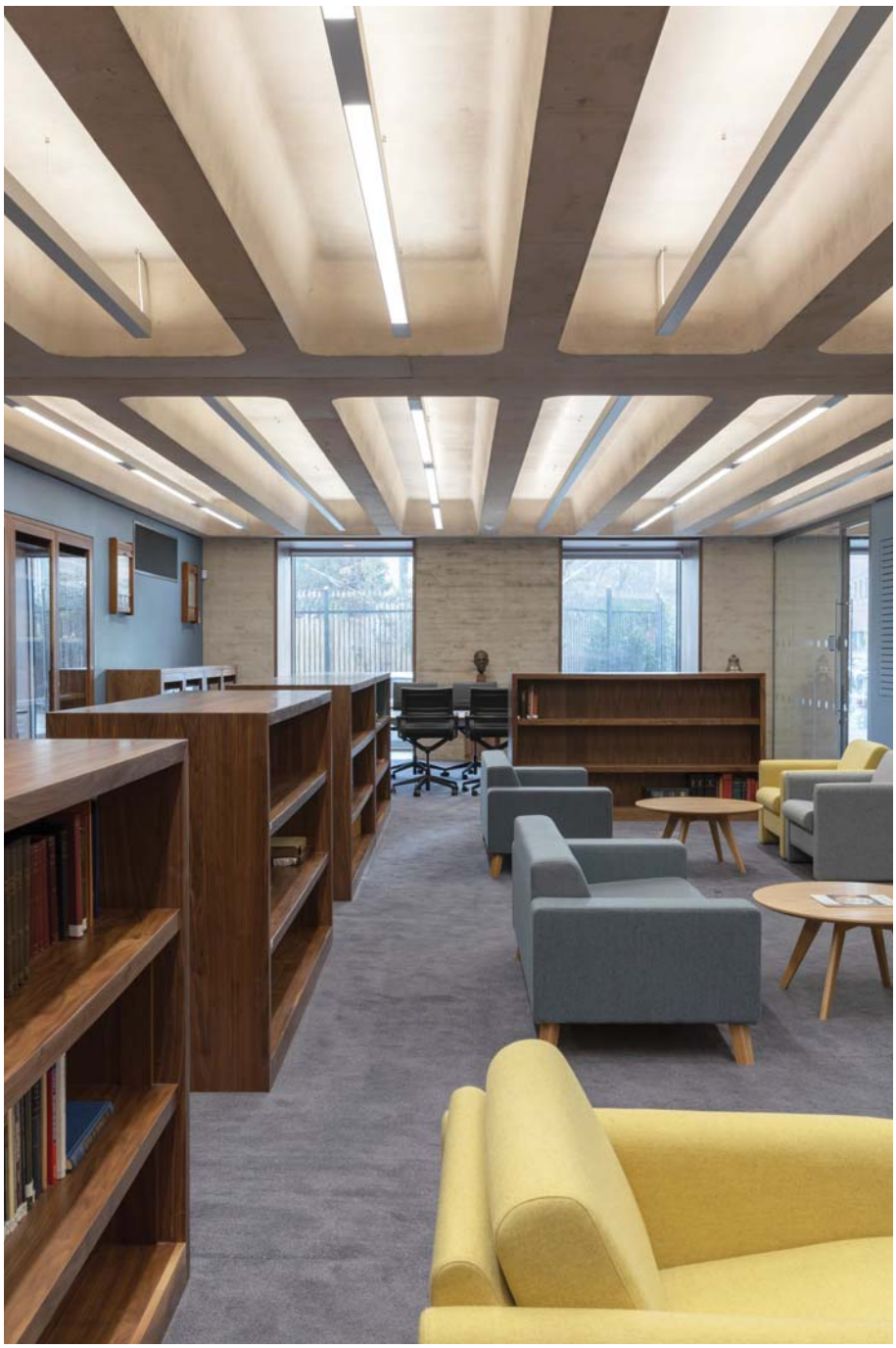
To minimise joint lines within the concrete surface, the formwork can be produced as single units for each coffer (the void between the ribs),

ABOVE:
Exposed concrete surface finish with two-way spanning ribs (Crossrail Farringdon Station).

Formwork – material type	Advantages	Disadvantages
Timber	Can be site-formed	Basic features/profiles only
	Relatively inexpensive	Accuracy and quality variable
	Can commence works quickly	Reuse limited
	Steep or no draft angles are achievable	Increased duration of site works susceptible to site conditions
EPS with polypropylene sheet	Can be manually handled	Limited complexity
	Easy to strike	Damage possible during reuse
	Reuse possible	Only compatible with certain release agents
	Reduced requirement for skilled site labour to create formwork	
Glass-reinforced plastic (GRP)	High-quality finish	Higher unit cost*
	Tight, bolted joints between units	Longer production lead times
	Multiple reuses	Larger, heavier units
	Dimensionally accurate and consistent	

** Number of uses should be considered when determining the cost per use.*

ABOVE:
Table 1 – material types for ribbed slab formwork – advantages and disadvantages.



but this may be impractical from access and handling perspectives; therefore, joints should be considered and expected within the design. The use of lighting that is sympathetic to this cause or the use of shadow gaps (recesses) may be used to soften the impact of, or even hide, the joints. Alternatively, if visible joints lines are inevitable, then purposely locating them via regulated or randomised location and position should be considered.

A trial or test panel can also be produced to help set expectations once a contractor has been appointed. This will also test factors such as the proposed method of construction, concrete mix design, suitability of release agent and the formwork placement/ striking method, with the latter being particularly important when forming a ribbed floor soffit feature.

The influencing factors that contribute to achieving the

LEFT:
Exposed concrete surface finish with one-way spanning ribs at Royal College of Pathologists.

TOP LEFT:
Striking of waffle moulds with tapered sides at Crossrail Farringdon Station.

TOP RIGHT:
Waffle moulds in position prior to concrete pour at Crossrail Farringdon Station.

specified finish of 'visual concrete' are extensive. With regards to the formwork system required, first it is vital that the appropriate formwork material is selected, based upon considerations that include the concrete finish it will provide and the complexity of geometry and installation/striking, which is especially relevant if the formwork is required to be reused for multiple pours. The same material type should be used as the casting face (the surface in contact with the concrete when poured) throughout, to avoid variation in the concrete sheen and tone. While site-produced formwork, commonly from timber, will prove adequate for lower-end finishes and more basic shapes, complex curving features are likely to require the involvement of a specialist formwork supplier who has CNC machining capabilities and access to a wider range of materials. Table 1 indicates the factors upon which formwork material selection should be made.

TROUGH AND WAFFLE MOULDS

When using both trough moulds for forming one-way spanning ribs or waffle moulds for forming two-way spanning ribs, the principle of installation is generally the same. Accuracy in setting out is critical to ensure rib centres and widths are in accordance with the design. Generally, these moulds are positioned upon a flat timber deck or table, supported by props on the underside. Individual moulds can be fixed into position by creating a reverse flange beneath them, which when fixed to the timber deck will not be positioned in the form face. These fixings can then be removed from below the supporting deck/table when the formwork system is struck.

Prior to the concrete pour, any gaps within the formwork system should be sealed to avoid grout loss and a suitable release agent should be applied. The influence of the release agent on the finished concrete surface is significant, and so a thin, uniform coating across the entire casting face is recommended, avoiding excess which will lead to blow holes and staining in the concrete surface. The timing of the release agent application is critical to maximise its effectiveness, as is the placing of reinforcement, the rust staining from which is commonly identified as the cause of localised discolouration in the exposed concrete finish. Spacers used to support the reinforcement should comply with BS 7973-2[2], with selection based upon the required cover, type, positioning and colour in case they are visible in the concrete upon inspection.

Concrete placement should be at a steady and constant rate from an appropriate height to avoid impact and displacement of the trough or waffle moulds. Air trapped within the concrete should be removed via vibration unless a self-compacting concrete is specified.

Once the concrete pour has been completed from above the formwork system, it should be left to cure before striking takes place. Striking is undertaken from the underside by removing the supporting props and deck, at which stage, some of the moulds may free themselves without intervention; any that remain in-situ should be removed with care so as not to damage the surface of the concrete and/or the moulds if they are to be reused. It is at this stage it becomes clear if sufficient release agent, or any at all, has been used.

Immediately after striking the formwork, the concrete is likely to have an unfavourable appearance, but it is vital that nothing is done in the form of remedial work until it has dried sufficiently, after which a more even tone and acceptable visual appearance is likely. Attempting repairs runs the risk of making the concrete surface worse and therefore a period of patience and contemplation is required.

While the primary reasons for designing ribbed slabs have evolved over time, the combined benefits from their structural performance and aesthetic appeal have remained unchanged. Whether the aim is to achieve a subtle differentiation or an eye-catching visual feature, the inclusion of an exposed ribbed slab soffit within a concrete frame design can achieve both, and everything in between. C

References:

1. NATIONAL BUILDING SPECIFICATION. *The Seven Cs of Specification*. NBS, Newcastle, 2018, available at: *https://bit.ly/3fq1Yqg*.
2. BRITISH STANDARDS INSTITUTION, BS 7973-2. *Spacers and chairs for steel reinforcement and their specification. Fixing and application of spacers and chairs and tying of reinforcement.* BSI, London, 2001.

LEFT:
Typical example of joint lines within a one-way spanning ribbed floor slab, Scottish Blood Transfusion Centre.

BELOW:
Release agent being spray applied to trough moulds prior to reinforcement placement, Royal College of Pathologists.