

A Guide to Specifying Visual Concrete

These notes have been prepared from direct experience and research on visual concrete production. The research on concrete finishes is published by the Concrete Society in the U.K. in 'Technical Document 52'. They have been drafted assuming British Standards.

It is important that the ready mixed concrete supplier is involved early in the discussion on the choice of concrete colour and finish, to check the availability of cement types, availability of special aggregate or pigments, and to agree on a practical and affordable concrete mix that can be supplied to the project. Consult with formwork, formliner and release agent suppliers to determine the best product(s) to achieve the required surface finish. Impart this information clearly and concisely in the specification to help the contractor to understand and price what will be required.

Seek advice from the research and marketing division of the cement and concrete industry. It is usually free.

The Concrete Mix

Concrete mix constituents shall be weigh batched and truck mixed generally in accordance with BS 5328 or European equivalent.

The proposed concrete shall comply with the requirements for fair face concrete work viz. cement type and content, pigment, water cement ratio, aggregate and sand content and not a strength criteria. The concrete mix in combination with the formwork and selected release agent – when properly placed and compacted – will produce a blemish free finish, free of blowholes and give a uniform surface colour appearance.

The proposed concrete mix shall be cast in a sample panel to prove the integrity of the concrete mix, the formwork systems and workmanship in meeting this requirement.

For general guidance the proposed concrete mix should comply with the following characteristic to satisfy uniformity of colour and surface finish.

1 The concrete workability shall be sufficiently cohesive for vibrator compaction, pump delivery, handling by conveyors and chutes on site, to free fall 2m, and to be placed in vertical forms without segregation or causing excessive bleed water to rise to the surface.

2 The concrete must have a cement content not less than 350kgs/m³ and must be taken from the same batch of cement to eliminate possible changes in cement colour. State what cement type is required – white cement – light grey GGBS cement or grey Portland Cement and describe what colour the concrete is to be.

3 The type of cement, cement content, water cement ratio, fine aggregate content less than 150 microns, pigment concentration and any approved admixtures shall be fixed for all concrete supplied to the contract and must not be adjusted at any time during the contract. Fine materials of particle size not less than 150 microns control the surface colour of the concrete. Pigments are the finest particles followed by cement and a small proportion of sand that is smaller than 150 microns.

4 The water - cement ratio shall not exceed 0.5. Once the ratio has been agreed by the architect following successful trial mixes and panel construction, it must not be adjusted at any time during the contract, as any variation in the total water content will effect the surface finish colour.

5 The total aggregate – cement ratio shall not exceed 6.

6 The sand - cement content shall not exceed 2. The sand should be a zone M or similar type sand without too much fine dust. Sand content expressed as a percentage of the total aggregate by mass should not exceed 40%.

7 Coarse aggregate 20 – 5 mm: not more than 20% to pass a 10 mm sieve.

8 Any plasticiser, water reducing admixtures or pumping aid used in the mix must be stated and their compatibility checked with the release agent. Some admixtures can react with release agents to create gas bubbles and this could lead to entrapment of blowholes on the concrete surface.

Production Quality Control

Truck delivery tickets must show the batch weights of all mix constituents, including the total water content and total water – cement ratio and show compliance with the approved mix constituents. They shall be given to the concrete contractor for recording and checking on arrival on site. If no delivery ticket is presented, the concrete shall be rejected.

Concrete shall be sampled from the truck mixer before discharge and slump tested to check the colour and uniformity of mix. If any noticeable colour variation is evident, then the concrete shall be rejected.

Accurate weigh batching and control of aggregate moisture content is essential in the production of good visual concrete. Store aggregates under cover in bins to prevent rain wetting stockpiles. Monitor moisture content of aggregates regularly and adjust free water content to maintain the correct water – cement ratio.

Wet batched concrete is preferable to dry batched concrete, as it eliminates the variability and uncertainty of truck mixing efficiency. Some trucks are not efficient concrete mixers, they can only agitate the mix because of the paddle configuration in the mixing drum.

Concrete Placing and Compaction

Clean and wet concrete skips, conveyors and any other concrete handling plant before use. Remove all discharge of grout in the pumping line and excess water as pipeline is primed. Place the first layer of concrete into position across the whole length of the formwork for a wall pour and roughly tamp to level. If necessary use the poker to melt the top of the high points in the layer before commencing poker vibration. The maximum depth of an uncompacted layer of concrete shall not exceed 50 mm. High frequency immersion poker vibrators shall be used with the right diameter to effectively vibrate the concrete to the full width of the form of the distance to the outside form face. The spaces between vibrating points shall ensure that the cone of vibration of the last position just overlaps the next vibrating position. The rate of concrete placing shall be uniform and must exceed 2m / hour in vertical sections.

Prior to commencing the work, the contractor shall be required to produce a sketch drawing of the pour planes and poker immersion points for a typical column and wall pour. This is necessary to show that the type and size of poker, and its radius effect of vibration will adequately compact the concrete layers and maintain an even compaction force at the form face, to ensure a consistent concrete colour. If the compaction on the form face varies greatly then this inadvertently causes dark and light colour variations to appear on the finished surface.

Use rubber linings over vibrating pokers for all compaction work to slab soffits. Do not use the poker vibrator to move concrete into place. Tremie or chute the concrete into positions for the vertical forms to avoid concrete splashes to the form face or segregation on the rebar, before it reaches the bottom of the pour. Spade the concrete near to the formwork face to release any air pockets. Do not place poker vibrators near the formwork face. This will avoid poker burns and noticeable variations in colour and aggregate density on the exposed concrete face.

Revibration

Revibrate concrete at the top of the vertical pour after 1 – 2 hours to eliminate colour banding due to excess bleed water rising to the surface.

Surface Tolerances

- a) Abrupt changes to formed surfaces: a max. deviation of (2 mm) is permissible between formwork panels.

- b) Formed surface imperfections: blowholes are permissible up to a max. size of (3 mm); their number may not exceed (10) in any square metre.
- c) Floor surface finish must be smooth with no abrupt changes. Variation in level must be not more than 5 mm in 3 m, in any direction.

Note: () modify figures according to required quality

Formwork

- a) Grout Tight Joints: The formwork shall be grout tight and all joints between panels sealed with an appropriate sealant to eliminate grout loss. The formwork and tie bolts shall be designed to resist a full liquid head, and high amplitude vibration during compaction and must not deflect more than 1/360. To prevent grout leakage at tie bolt holes, use plastic snap-tie cones with rubber gaskets on the tie.
- b) Release Agent: Use only neutral pH, non staining release agents which when applied to the formwork will not wash off during rainy weather. It shall adhere to the formwork and debond the concrete effectively while the forms are in place (up to 36 hours) without causing blemishes, discolouration or blowholes to form on the surface finish or later cause the surface to dust. Evidence that a proposed release agent complies with the requirement must be proven.
- c) Construction Joints and Panel Layout: Rebates shall be formed at concrete construction joints to form a neat edge to the construction joint. The position and detail of all construction joints shall be shown on the contractor's falsework drawing, together with a layout of formwork panels and tie-bolt hole positions for approval by the architect, prior to the commencement of concrete work.

Formwork Striking Times: Formwork shall be stripped about 24 – 36 hours after casting. This will give a consistent colour to the concrete and avoid exposing the forms to prolonged heat by hydration and chemical action of the concrete in breaking down the release agent. It is important to strip formwork to give the same equivalent maturity time throughout the project as even small variations in maturity time can cause colour variation between panels. Maturity time will be less in hot weather than cold weather, and these times can be evaluated from cement content and actual concrete curing temperature.

Making Good: No making good shall be permitted to certain surface finishes indicated on the drawings. In all other areas making good may be permitted subject to approval by the architect and to a standard that matches the reference panel.

Reinforcement; Supply clean cut reinforcement, with no rust marks, for all exposed concrete work.

Cover and Spacers; Cover to slab and walls shall not be less than durability requirements shown on the structural drawing. Spacers for slab and wall reinforcement shall be of plastic construction, rigid enough to maintain rebar cover without deformation and small in contact area with formwork to avoid marking the exposed concrete face.

Curing: Direct wet curing of concrete or wrapping concrete in polythene sheeting is not permitted, as this will cause dark and light patches to form which may not fade in time. Maintain a small but definite air space between any impervious protection such as polythene or tarpaulins to avoid direct contact with concrete. Curing membranes are not permitted as they will stain and prevent any coatings bonding to the surface. It may be best to do nothing if after removal of the formwork the surface has hardened sufficiently and will not dry out prematurely and become dusty.

Reference Panel: The reference panel should be a full storey high and bay width panel. If form liners are used the panel should be at least two liner panels wide to observe the vertical joint. The finished result should be a true reflection of the quality of the workmanship, curing and construction method.

Formwork, formliners, mix design materials, release agent, concrete handling and compaction procedure and the actual operatives that will be deployed on the job should be involved in the casting the panel. Patch repairs of blowholes (should that be permitted), location and filling of tie-bolt holes, and such like should be evaluated and agreed at the same time. If the surface is to be rubbed, etched, mechanically abraded and / or coated with water repellent covering to eliminate dirt staining or water absorbency then this treatment shall be carried out. In this way the quality of the finish can be agreed, highlighting areas for possible improvement and setting the standard for the project. The surface finish may include small variations in tone even if the work has been done correctly, but these are likely to be distributed randomly over the whole surface rather than being concentrated in one spot.

Consideration should be given to a sensible viewing distance for the reference panel, as scrutiny from close quarters would be unreasonable unless particular sections of work merit such inspection. In this event consideration should be given in the contract bill to prepare and cement wash the concrete face to produce an even blemish free finish, if that is what is desired. This is a very subjective judgement. Most architects prefer to leave the surface untouched, to show the natural grain of minor imperfections – the blowholes and blemishes – rather than cover them with a veneer of cement slurry or cement wash which make the surface look painted and plastic.

Quite often the finish tone of grey or white concrete can become an issue, because the architect or client is undecided on the final colour. There is no definition by which the quality and colour tone of the finish can be unequivocally described by specification alone. The same concrete mix poured into different formwork or placed in the same formwork at different temperatures, or retained in the forms for different lengths of time will result in colour variations. The longer the concrete is cured or retained in the forms the darker the surface tone. It would be prudent to conduct colour sample trials with the concrete supplier making concrete cubes or small panels of concrete, prior to commencing an expensive, full scale reference panel.

Compliance

Having verified to the architect or his / her representative that concreting procedures have been carried out correctly, the concrete supplied is to specification, formwork panels cleaned and prepared and removed diligently, taking every care to maintain the same quality of workmanship as the reference sample with no change of site operatives, then the resulting concrete finish shall be deemed to satisfy the specification, provided that a) blowholes are less in diameter than the specified maximum and the number less than the number specified per square metre and match the reference panel; b) there is no honeycombing from grout loss or the like; c) the blemishes to the surface are no worse than the reference panel; d) alignment and surface tolerance are within specification; e) making good where permitted brings the surface finish to within compliance standard. Otherwise the concrete shall be rejected and the work redone.