

Quality Assurance of Precast Concrete Product

by

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Program for Today:

Introduction to QA of Precast Product

Some new and innovative ways to assist in QA of precast



Definition.

“ The manufacture of off-site, moulded, or formed product using a hydraulic cementitious material as a binder to construct a useful product or shape.”



Examples of Precast Products







SCCT ACS 2006





What are the different precast products requiring QA.

Simple Answer :- All

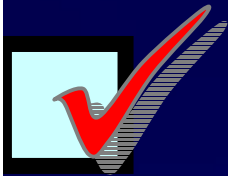
Plant certification Classified into 4 main groups

Architectural
Bridges
Commercial
GRC

Refer to www.pci.org for further details



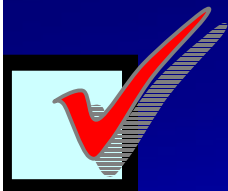
Main Components of Precast QA System



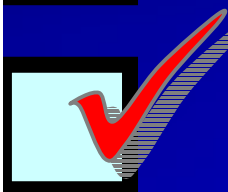
Quality System



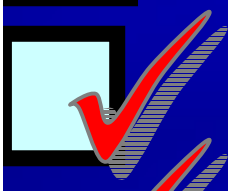
Production Practices



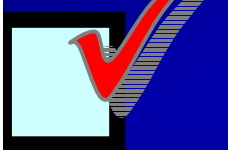
Raw Materials and Accessories



Concrete



Reinforcement and Stressing,



Quality Control/ Acceptability



Main Components of Precast QA System **Quality System**

Extract from cl.4.1.1 of Code of Practice
For Precast Concrete Construction 2003 issued by BD

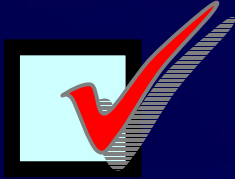
“A factory selected for the casting of units must ensure that the precast units are manufactured under a Quality Assurance Scheme certified under ISO 9000 covering the following items:

- **quality control tests of materials;**
- **calibration of laboratory equipment for quality control tests; and**
- **production process and control of equipment at the casting yard”**



Main Components of Precast QA System

Production Practices



- **Safety**
- **Production and Curing Facilities**
- **Moulds**
- **‘Hardware’ installation**
(e.g. anchor bolts, plates, windows, tiles, etc)
- **Handling**
- **Surface Finishes**
- **Repairs**
- **Acceptability of Appearance**
- **Sealers/coatings**
- **Etc, etc.**



Safety

- With nearly precast plants for supply to HK in Guangdong Province safety of all personnel is obviously a high concern.
- Safety is difficult to achieve given the lack of education/understanding of the labourers. But precasters do try their best with the available resources and it is an uphill battle that they are continually facing.
- To date levels of reported incidents of serious safety issues at precast facilities is low.



Production and Curing Practices

- **Suitable to ensure samples/moulds are protected against detrimental environment conditions.**
- **Adequate lighting for all operations**
- **Ideally 'maintain suitable ambient temperature within production area'**
- **Mould Fabrication facilities (some local precasters make there own !)**
 - a. **capable of providing moulds of the required accuracy**
 - b. **Moulds stored appropriately to avoid damage/change of dimensions e.g. due to excessive temperature**
 - c. **Use qualified Design Engineers / Specialists**



Production and Curing Practices

- Suitable Storage of Materials
- Hardware Fabrication and Storage (to avoid distortion and other affects) – External records for outside suppliers.
- Casting Area and Equipment
 - Sufficient and suitable equipment.
 - Flexibility in planning spacing of moulds and movability of workers, materials and product.
 - When stressing activities performed – separate distinct/secure area.
 - Sufficient Ventilation for certain applications.



Curing Areas

- **Most curing is by using ambient (covered in polyethylene or wet hessian) curing conditions (Normally cured for at least 4 days)**
- **Sometimes Steam curing used to ensure one-day production cycle (or more frequent) – common practice is to control temperature (~55+/-5°C) of steam at suitable 'agreed' locations near the surface of the element by use of thermocouples. The steam is applied 4 hours after pouring at a rate of 10°C per hour ensuring concrete temperature does not exceed 70°C (e.g. Segments). When cooling same rate applies.**
- **Power regulated Heat Lamps are occasionally used for certain applications instead of steam (e.g. curing of LVT Blocks).**



Materials and Construction

- Moulds maybe made of a variety of materials.
- Stable to produce required finish and tolerance
- Some may be reused many times others maybe one-off. For reusable moulds checking of moulds before reuse is required
- Appropriate selection of mould type and quality. The appearance of finish is directly related to the choice of mould material and quality of the mould.
- Selection of Mould Release agent will be dependent on type of mould and possible affects on finish (e.g. discolouration/staining)



Moulds

**Split, Single
or Multiple Moulds**



Moulds from Different Materials (Timber, GRP, GRC, Steel or Rubber)



Moulds

Verification and Maintenance

- **Mould Surfaces and dimensions checked in detail against design drawings before casting. (normally dimensional/ flatness / squareness / twist/ straightness / visual checks)**
- **Moulds have to be cleaned and inspected before each use. Inspection to look for defects/contaminations that may affect appearance/performance and correct assembly with design drawings.**
- **Templates (used for flatness checking etc) and other equipment used to verify moulds also have to be inspected and maintained regularly.**
- **Mould Release agent applied evenly without ponding.**



Finishing Areas

Depends on the type of product, some products no finishing treatment required prior to storage and delivery others may require extensive treatment.

For the latter case **good lighting** is essential at the point where final inspection takes place. Lighting should be as close possible to the actual lighting conditions of the product when in service.

Also the area shall contain all the elements necessary for the appropriate finish to be applied (more detail later)



Handling Equipment

The type, capacity of equipment for handling finished products depends on the product and its operating conditions

Equipment maintained in good working order to be Capable of stripping, moving , stacking, retrieving , loading units without damage.

Storage Area for Finished Products

Adequate size for safe (damage free) storage , easy access (required for inspection) and handling of products.

**Area should be clean, well drained and stabilized.
Storage conditions will be dependent upon product.**



Handling

The handling method depends on the type of product

- **Susceptibility to damage.**
- **Size / Weight of the product**

Suitable procedures required for each product type to allow for demoulding, lifting, storage and preparation for transport.

The handling has to ensure that structural damage, detrimental cracking, architectural impairment or permanent distortion are avoided.



Yard Storage/Loading.

- **Careful Planning,**
- **Units generally supported with 2-point supports spaced at about 1/5th point.**
- **Stored on firm and level ground.**
- **Stored & Loaded in a way to protect from damage, discolouration or staining of finished product.**
- **Stored and loaded in a suitable manner to allow for moving at later stage.**
- **Stored and loaded using even loading to prevent domino effect.**

Cleaning

- **All exposed surfaces of units cleaned as necessary prior to shipping to remove dirt, stains etc.**



Storage



Sealers or Clear Surface Coatings

- **When Specified Precasters use sealers/clear surface coatings after surface finish accepted.**
- Architectural Concrete normally do not use sealers for waterproofing.
- **Sealers used have to be checked before use to ensure that they do not cause stains , darken , discolour the finish or cause similar effects to any joint sealants that maybe present.**



Hardware Installation

All Hardware checked prior to casting to verify

- **Correct size and Type**
- **Sufficient Quantity**
- **Coating**
- **Accuracy.**
- **Strength.**
- **Correct Alignment/positioning.**

**During casting hardware also checked to
Ensure that they have not moved and
concrete around them consolidated correctly**



Stripping, Lifting

- Tests performed to confirm that concrete strength achieves requirement for stripping, detensioning and lifting. (Precast Code of Practice PNAP 286)

Table 3.2 – Recommended minimum concrete strengths for lifting and handling

Application	Minimum concrete strength
None specified, fine controlled crane, non-prestressed	10 N/mm ² *
Lifting which involves significant impact or high acceleration	15 N/mm ² *
All units where concrete strength for lifting is specified in the contract documents	as specified
Centrally prestressed elements (piles, wall panels or thin floor slabs)	20 N/mm ²
Eccentrically prestressed elements (tees, deep flooring units)	25 N/mm ²
Bridge beams and similar highly stressed prestressed elements	30 N/mm ² or as specified
*Dependent on anchor length or as recommended by insert manufacturer	



Stripping

- Tests performed to confirm that concrete strength achieves requirement for stripping, detensioning and lifting. (Precast Code of Practice PNAP 286)
- All removable inserts, fastenings, mould parts released and/or removed prior to stripping.
- Units uniquely identified in appropriate place to include cast date or serial number.
- Surface of Unit checked for damage



Surface Finishes

How to ensuring quality of finish !.

First all parties agree on the acceptable type of finish

This is achieved by using by various ways



Surface Finishes

Specifications (e.g. Civil Eng Spec Volume 2, Particular Specification stating tiling requirements etc..)

Table 14.3 : Treated finishes

Table 14.1 : Formed finishes

Class of finish	Type of formwork normally used	Characteristics of finish			
		Formwork pattern	Abrupt irregularities permitted	Gradual irregularities permitted	Specific requirements
F1	Sawn timber	Not required	< 10 mm	< 15 mm in 2 m	No specific requirements
F2	Plywood	Pattern of formwork joints and tie holes as stated in Clause 14.30(1) and (2)	< 5 mm	< 10 mm in 2 m	Even surface No grout runs
F3			< 3 mm	< 5 mm in 2 m	Even surface No grout runs
F4					Uniform, dense and smooth surface No grout runs No grain pattern No crazing No major blemishes
F5	Sealed plywood		< 2 mm	< 3 mm in 2 m	Uniform, dense and smooth surface No grout runs No grain pattern No crazing No blemishes No staining or discolouration



Surface Finish

Initial standard points of reference.

**Refer to PCI –Color Texture Guide at
<http://www.pci.org>**



Surface Finishes

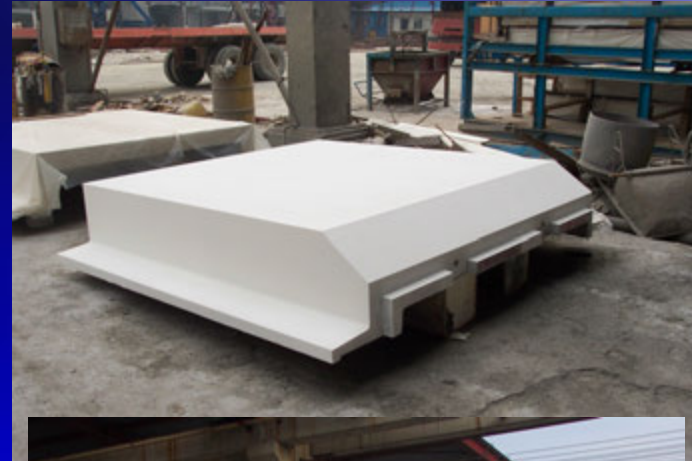


Mock-up/Control samples with varying levels of colour/ acid etching/ tooling etc

Do Not use one sample as control use a series or range !.



Painted Finishes



Acceptability of Appearance

- **Agreement on how to accept finish (lighting requirements / colour (range) requirement/ intensity of shade requirements / depth of etching etc...)**
- Generally Subjective individual judgment. Standard Rules therefore difficult.
- **“Finish face surface shall have no obvious imperfections other than minimal colour and texture variations from the approved samples or evidence of repair when viewed in good typical daylight illumination with the unaided naked eye at 6m viewing distance.”**
- Colour variation will vary greatly with different colours , e.g. white will have minimal variation whereas something such as dark blue is difficult to control.
- **Also Note ensure persons assessing and / or accepting do not suffer from colour deficiency**



Repairs

- **A certain amount of Repair Should Always be expected.**
- Repair normally requires a lot of care and should always be performed by experts.
- **Selection of the appropriate repair material to ensure that the end-product may be structurally sound , durable or visually acceptable and all of these not impaired by the repair.**
- Excessive variation in colour or texture of repairs from the surrounding surfaces may result in the panels being not approved until the variation is minimized.



Repairs

- Repairs should be done prior to being placed in the storage area.
- Colour variations between new and old samples will always be evident. Repairs differences will blend in time (several weeks). Earlier repair made normally the better.
- If Substantial variation in colour and texture of repairs from the surrounding area occur, the repair may be required to be removed and new repair material installed.
- Small cracks ($< 0.25\text{mm}$) may not need repair unless failure to do can cause corrosion of reinforcement.



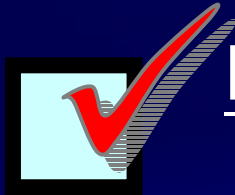
Repairs

How are common repairs normally performed.

- **Filling Cracks with epoxy**
- Filling imperfections (blow holes, water holes, exposed aggregate , bleed scarring etc) with cement sand (or CRF) mortar / brush or rub into place with latex or similar material as gauging medium. Care required as may cause colour variations
- **More Acid Etching/sandblasting (make it lighter)**
- Removal of stains (removal depends on type of stain)
- **Blending pigment slurry into the repair area.**
- Breaking out and Reinstatement.
- **Many others**



Main Components of Precast QA System



Raw Materials and Accessories

* Concrete Materials

(Concrete Materials Comply to the requirements of HKQAA QSPSC (or equivalent) plus any other additional Specification requirements)

* Reinforcement and Hardware

(Comply to the requirements of CS2 / BS 5896 / BS4482/ BS4483 and/or other additional Specification requirements)

* Others

(Window frames, Tiles, Insulations, Conduits for E & M Fixings, lighting, TV ..., Waterproofing, Welding for Hardware Etc..)

•Precasters arrange testing to be performed of the materials at HOKLAS accredited labs (or equivalent) if available prior to use and acceptance.

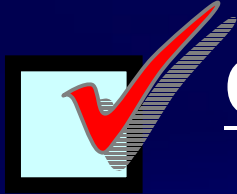


Raw Materials Others

- **Window frames**
- **Tiles**
- **Insulations**
- **Conduits for E & M Fixings, lighting, TV ...**
- **Waterproofing**
- **Welding for Hardware**
- **Etc..**



Main Components of Precast QA System



Concrete

- Concrete Comply to HKQAA QSPSC (or equivalent)
- Coloured Concrete comply to QSPSC (or equivalent)
- Glass Fibre Reinforced Concrete
comply to ISO 9001 & BS EN1169



Reinforcement and Stressing,

- Storage
- Installation
- Tensioning
- Pre-tensioning
- Post tensioning



Main Components of Precast QA System



Quality Control/ Acceptability

- **Inspection**
- **Testing**
- **Records**
- **Laboratory**
- **Analysis**



Inspection (Internal and/or External)

- **External Inspections**
 - HKIAS
 - HKHA Q-Plus
 - PCI
- **Internal Pre and Post pour Inspections.**
 - Inspections have to be managed in an efficient manner so as not to cause downtime for production/delivery and yet ensure that the product meets all set requirements.
 - Number/Qualification of persons performing inspection directly related to complexity of product and number of samples
- **Scope of Inspection**



Scope of Inspection

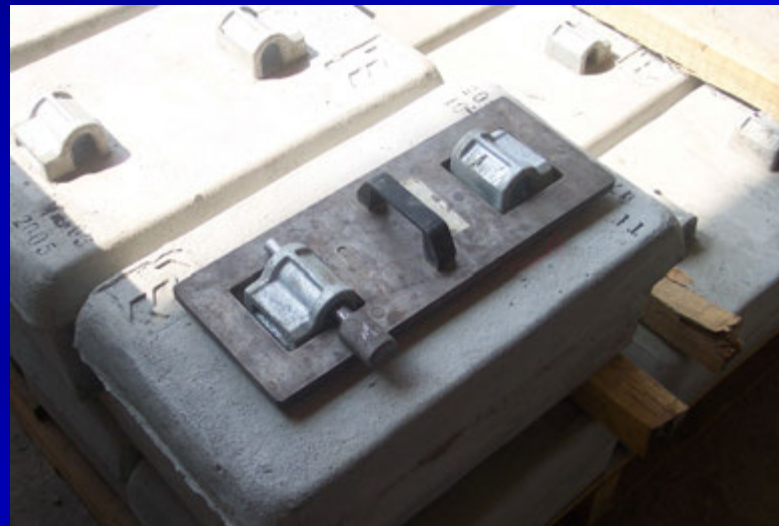
- **Plant testing of materials for acceptance prior to initial placement and daily check testing for maintenance**
- **Mix Design and routine concrete testing.**
- **Inspection of Moulds (moulds for tightness, flatness, squareness, dimensions , condition etc) and new set-up changes prior to pouring.**
- **Checking of quantity/location/positioning of cast-in items, reinforcement and other critical items.**
- **Inspection of batching, mixing , placement, compaction, curing and finishing**
- **Inspection of demoulding, product identification (cast number/cast date/job number), condition, etc.**



Scope of Inspection

- General observations of plant, equipment, working conditions and other items that may affect production.
- Preparation of specimens for lab tests
- Inspection of finish
- Check finished product against drawings/approved samples
- Inspection of storage, checking method of storage , contamination , conditions etc.
- Final Inspection of product during loading for proper blocking, detection of stains, cracks and other defects.
- Inspection of product following repair.





Quality Control/ Acceptability

Testing

- **Internal Plant Quality Control Monitoring.**
- **Product Approval (normally HOKLAS endorsable report)**
- **Ideally Testing performed at the precast facility**
 - a) **eliminate delays in production,**
 - b) **provide adequate product assessment,**
 - c) **ensure proper curing of samples.**





Quality Control/ Acceptability

Testing

Internal Plant Quality Control Monitoring.

- **Daily (or more frequent) Material Evaluations (moisture contents/grading of aggregates)**
- **Routine Fresh Concrete (e.g. slump, temperature etc) and Hardened Concrete Tests (cube strength for demoulding strengths, lifting strengths etc) to CS1**
- **Routing GRC Tests (BSEN1170).**



Quality Control/ Acceptability

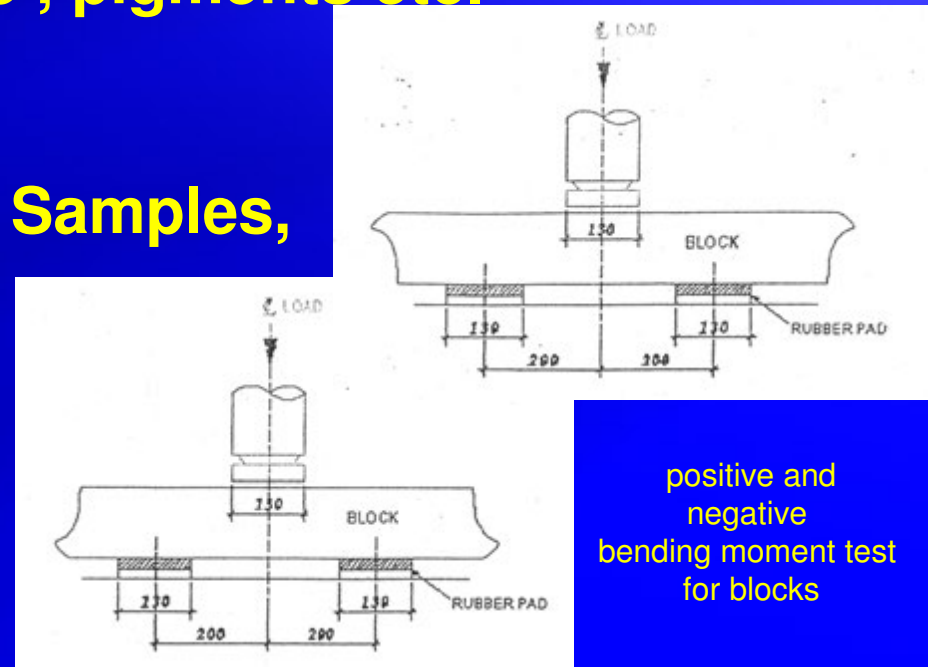
Testing

Product Approval.

- Material Testing
Cement , aggregate, fibre , pigments etc.

- Routine Product Testing
Slump , Cubes , Flexural Samples,
Production Samples etc.

- Special Testing



positive and
negative
bending moment test
for blocks



Quality Control/ Acceptability

Records

Many records are required for precast concrete.

- **Standards and Specifications**
- **Design Approval Records**
- **Testing of materials**
- **Concrete Mixing and Inspection Records**
- **Production Records**
(Testing / Pour/ Stressing etc).
- **Maintenance Records**
- **Repair Records**
- **Supplier Records**
- **Other Quality (ISO 9001) records.**





Quality Control/ Acceptability

Laboratory

Laboratory should be recognised by a accredited body such as HOKLAS to ensure it is competent to perform tests.

- **Sufficient Equipment for performing tests including curing.**
- **Calibrated/Maintained Equipment.**
- **Properly Trained Staff.**



Quality Control/ Acceptability



Analysis and Acceptance

Data (Product) obtained throughout the process is normally analysed using various techniques, these include;

- **Individual Material/Product Compliance evaluations**
- **Statistical Evaluations**
- **Once all data has been accepted internally by precaster then data (product) is inspected for client approval prior to shipment.**



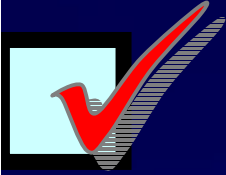


**Some new
innovative
assist in QA**



**and
ways to
of precast**

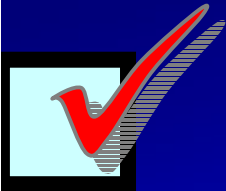
New & innovative ways to assist in QA of precast



Product Certification



Use of RFID



**Example of how the established
precasters are working with
International Institutions**



New & innovative ways to assist in QA of precast Product Certification

**HKAS Offers via The Hong Kong Certification
Body Accreditation Scheme (HKCAS) the
service of accrediting organisations for
product certification for precast concrete.**

**Details are referred in the document
HKCAS Supplementary Criteria No. 2
Accreditation of Construction Product
Certification
Download from <http://www.itc.gov.hk/>**



New & innovative ways to assist in QA of precast

Product Certification

With Individual Product Certification / Marking, confidence in products acceptability will be enhanced.

Furthermore the Quality of the precast operation will hopefully be improved.



RFID Tracking for Precast

How Tracking works ?

The process is similar to the Current Cube System except:

- 1. The type of tags used are normally active rather passive.***
- 2. The tags are cast into the concrete element***
- 3. The information is uploaded throughout the Precast construction process onto the tag, hence the amount of data on the tag is far greater.***



Tracking Concrete Products

What information is Tracked ?

- *Element Design Plans*
- *Reinforcement Details*
- *Test Data (Materials and End-Product)*
- *Casting/Handling /Erection Procedures*
- *Records:- Inventory , Maintenance, Safety, Delivery , Audits*
- *Security Access*



*Other ways RFID can be used for precast concrete
(System for Making Test Measurements)*

How System works ?

- Tags Used are Active so that they can 'chirp -out' test data at regular intervals***
- Tags are of a different design as they incorporate two items – namely The measurement sensor and the RFID transponder***



***Potential Applications of RFID for Precast
In the Medium - Long Term***

- 1. Fire and Heat Warnings.***
- 2. Thermal Losses of Buildings through wall panels***
- 3. Moisture / Relative Humidity monitoring of panels.***
- 4. Monitoring gas penetration through panels***
- 5. Monitoring movement of installed Wall panels***
- 6. Monitoring acoustic properties of products.***



Precasters working together with institutions/associations

PCI - Precast Prestressed Concrete Institute of USA;

ACI - American Concrete Institute;

**GRCA- Glassfibre Reinforced Concrete Association /
Concrete Society;**

(HKCA) Hong Kong Construction Association

And many more ...



Research & Development

- » New Mix Designs
- » New Manufacturing Techniques
- » Use of New Materials
- » Development of Software
- » Laboratory Testing



Summary

- Precast QA depends entirely on the end-product, it can sometimes be very complex but on other occasions very simple.
- It is essential that the inspectors and end-users fully understand how the precast products are manufactured and how they are intended to be used including limitations
- Realistic agreement on what is truly acceptable.
- Nearly all 'local' Precast Contractors factories are in Guangdong and this limitation is a very important consideration when specifications are devised and implemented.



Thank You

Many Thanks to the following for their kind co-operation with this presentation

1. Quality Control Consultants Ltd.
2. Redland Precast Concrete Products Ltd (Precast Photos)

