

# DESIGN MANAGEMENT FOR CONSTRUCTABILITY REVIEW OF HIGH QUALITY EXPOSED CONCRETE

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**ABSTRACT :** This report is to do design management for constructability review of high quality exposed concrete, which is used increasingly in recent. To secure systematic management at design phase, we reviewed each definition and work at each design phase, we define high quality exposed concrete, a part of architectural concrete, as "an exposed concrete which has well ordered joint & is in pursuit of smooth surface." We reviewed requirements and influential factor to obtain High quality finishing surface and compared construction process of high quality exposed concrete with that of other finishing method. Management method at each design phase for constructability review to meet additional works and requirements is presented.

*Key words :* Constructability Review(CR), Exposed Concrete, Design Management

## 1. INTRODUCTION

Exposed concrete has applied mostly to the monumental architecture according to design concept, since Le Corbusier designed La Capelle de Ronchamp in 1955.

In the first stage exposed concrete of rough texture took the most part, but as the development of execution method and the improvement of concrete quality and so on, the high quality exposed concrete began to be used increasingly.

High quality exposed concrete attracts public attention as the finish for various expression of elevation lately. Though recently applied high quality exposed concrete needs more careful and professional supervision work, the architect and client don't have enough understanding on this matter and constructability review for getting high quality exposed concrete is not exercised on the designing phase.

Consequently, additional shop drawing and change of design become necessary, and because of crack and stains on the surface, deterioration, delay & expense increase may be raised as a problem.

Therefore, this study is to review the definition and work on each phase for more systematic design management, to make the definition of high quality exposed concrete clear, to compare it with other finish about execution process, and to propose a way of design management in consideration of requirements as specific.

## 2. PRELIMINARY CONSIDERATION

### 2.1 Definition of High Quality Exposed Concrete

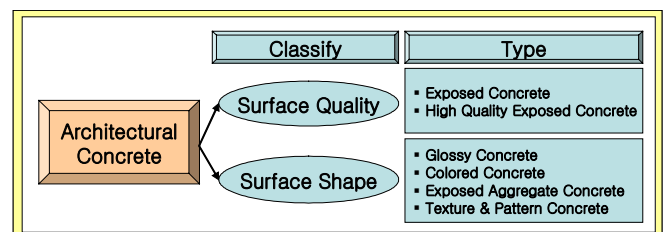
Exposed concrete basically means exposing the surface without additional finish. The definition of exposed concrete from existing documents is as Table 1.

**Table 1.** Existing Definition of Exposed Concrete

Source	Definition
Architectural work Standard Specification, Architectural Institute of Korea	(1999) Do not exist. (2005) Concrete finish by itself, scrape or grind concrete surface for the use of slab, wall and ceiling
Architecture Dictionary, Sungandang, 2004	Remove forms and expose the concrete surface as it is
Lim Nam Gi, the Development of Checklist, Architectural Institute of Korea, 2005. 1	Finish the concrete surface with color & texture of concrete itself without additional finish. Doing structural work and finish work at the same time.

Definitions above defined in common surface is exposed on the outside, but doesn't have clear definition according to concrete quality, for example surface texture.

Abroad high quality exposed concrete and exposed concrete are considered as a part of architectural concrete in broad way and is defined collectively. Classification of architectural concrete as surface quality and surface texture is as below. Figure 1.



**Figure 1.** Type of Architectural Concrete

High quality exposed concrete and exposed concrete have different quality degree and supervision work level according to the difference of design & execution grade, color & texture on finish. Exposed concrete is only for plain surface, so it has least importance on supervision work and sometimes it doesn't need to do finish, but because of the rugged surface, painting is necessary after surface treatment.

However, high quality exposed concrete needs additional detail drawing in the phase of design, therefore it is in pursuit of precision execution, color equality and high quality texture. it uses the surface after removing form and also uses water-repellent agent as requirements. For the difference about execution method, supervision work and itemized statement, the concept of exposed concrete and high quality exposed concrete should be divided. In this study, 'High Quality Exposed Concrete' is defined an exposed concrete seeking well ordered joint and cone hole, smooth surface.

### 2.2 Study of Design phase for Constructability Review

At first, the definition of constructability should be clear at first for the design management of constructability review. the existing definition of constructability is as Table 2.

**Table 2.** Definition of Constructability

Organization	Definition
CII, USA	Constructability - The effective and timely integration of construction knowledge and experience with project planning, design, procurement, and field construction operations
CIRIA, UK	Buildability - Design standard of how to meet requirements and to make it easily
Japan	Production design - Management technique of design review to increase realization, considered economical efficiency & quality

This study has a purpose to propose a way of design management to make sure constructability of high quality exposed concrete on the design standard of how to meet requirements and to make it easily.

For the orderly management, the order is like as follow : pre-design, schematic design, design development, construction document. And the definition of each phase is as Table 3.

**Table 3.** Design phase & Definition

Phase	Pre-Design	Schematic Design	Design Development	Construction Document
Definition	Investigates design concepts that consider the environment, climate, building orientation, conditions and requirements.	Resolves and develops the building and site elements. Quality & performance standards on materials & systems are developed.	Refine the project and confirm that target can be achieved. Include the goal in specification language.	The final development of the working drawings and the project specifications. The complete set of document for construction will be developed

As design has a critical influence on the whole project, it will be favorable to enhance the productivity of whole project with design management. Therefore, we are going to propose a design management plan as the definition and work on each phase.

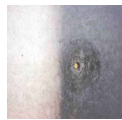

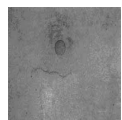

### 3. REQUIREMENTS & EXECUTION PROCESS OF HIGH QUALITY EXPOSED CONCRETE

Requirements and execution process work are added for high quality exposed concrete. For effective design management, we should recognize the requirements to obtain high quality finish and consider additional work in compare with other finish and execution process.

#### 3.1 Requirements of High Quality Exposed Concrete

As of high quality exposed concrete, color equality, restraint of crack, concrete filling efficiency and resistance of material separation, durability should be put more emphasis, compared with general concrete and exposed concrete. To meet this performance, consideration and recognition for securing quality for performance of concrete finish, constructability review and supervision work are important on designing. Requirements of high quality exposed concrete and the influence and defects are as Table 4.

**Table 4.** Requirements of High Quality Exposed Concrete

Requirements	Influence	Defects
Color Equality	<ul style="list-style-type: none"> <li>•Material (Cement, Aggregate)</li> <li>•Mix design &amp; Proportion</li> <li>•Form &amp; Form oil</li> <li>•Concrete admixture</li> <li>•Method of concreting</li> <li>•Once quantity of concreting</li> <li>•Curing condition</li> <li>•Leaking of Form or Cone</li> </ul>	 <p>Leaking of Cone</p>
Crack Restraint	<ul style="list-style-type: none"> <li>•Unpreparedness of crack induction joint</li> <li>•Crack Restraint Plan for Opening &amp; Protrude Shape</li> <li>•Drying Shrinkage</li> <li>•Vibrating / Curing</li> <li>•Strong-Wind / Scorching heat</li> <li>•Drying Shrinkage periphery Openings</li> </ul>	 <p>Shrinkage Crack</p>
Concrete filling efficiency & resistance of material separation	<ul style="list-style-type: none"> <li>•Slump</li> <li>•Aggregate size</li> <li>•Concreting Method</li> <li>•Vibrating</li> <li>•Reinforcement interval</li> <li>•Thickness of cover concrete</li> </ul>	 <p>settlement crack</p>
Durability	<ul style="list-style-type: none"> <li>•Lack of concrete cover for reinforcement</li> <li>•Neutralization</li> <li>•Reinforcement corrosion</li> <li>•Water-repellent agent</li> </ul>	 <p>peeing</p>

Typical defects, which are caused by insufficiency on requirements, are crack, peeling, surface roughness, stains on the surface, leaking, reinforcement corrosion, strength reduction, so the preventive method against defects should be prepared on each phase.

### 3.2 Compare High Quality Exposed Concrete with other finish about execution process

High quality exposed concrete needs additional work to secure high quality finish on the execution process in comparison to exposed concrete and general concrete. Execution process according to finish method is as Figure 2.

Along with the execution process, high quality exposed concrete requires more supervision work because it needs additional work at form work, pour concrete & tamping, upkeeping comparing that of finish.

## 4. CONSTRUCTABILITY REVIEW FOR HIGH QUALITY EXPOSED CONCRETE

It is favorable to do design management for constructability review as the definition and work along with each phase.

### 4.1 Pre-Design Phase

When high quality exposed concrete is applied, feasibility study should be ahead considering site condition, client's requirements and design concept.

Architects should recognize the definition and the scope of application of high quality exposed concrete and suggest the scope and design concept to clients.

Consistent use of the term may prevent from occurring confusion on design and supervision work.

### 4.2 Schematic Design Phase

(1) To Present Clear Quality Standards of high quality exposed concrete.

In case of high quality exposed concrete, correct quality should be written on drawing because execution method and process, cost are increased along with quality standard. For the better quality condition applies on it comparing to general concrete & exposed concrete.

#### (2) Decision of Texture

The finish of high quality exposed concrete has different image according to the finish method : glossy, colored, exposed aggregate, texture & pattern, high quality exposed and so on. Therefore, we should make it clear which image will be applied in advance.

#### (3) Recognition on Construction Expenses & Term of Works

Examine cost estimation according to quantity & cost per unit considering execution process and supervision work of high quality exposed concrete. But, at this moment the standard is not clear, so it should be discussed among client, architect and contractor.

### 4.3 Design Development Phase

#### (1) Decision on Surface Division

The whole image of high quality exposed concrete is fixed as the surface division by plywood & joint.

Plywood is a standard module of 3'×6' or 4'×8', the examination on the vertical & horizontal of connection, dimension & interval of joint and detail drawing by building elements are necessary.

#### (2) Appropriate Elevation & Section for High Quality Exposed Concrete

As high quality exposed concrete doesn't need to use forms less than other finish, if it is possible, shirk complicated elevation, it may cause expense increase, it should design repetitive elevation.

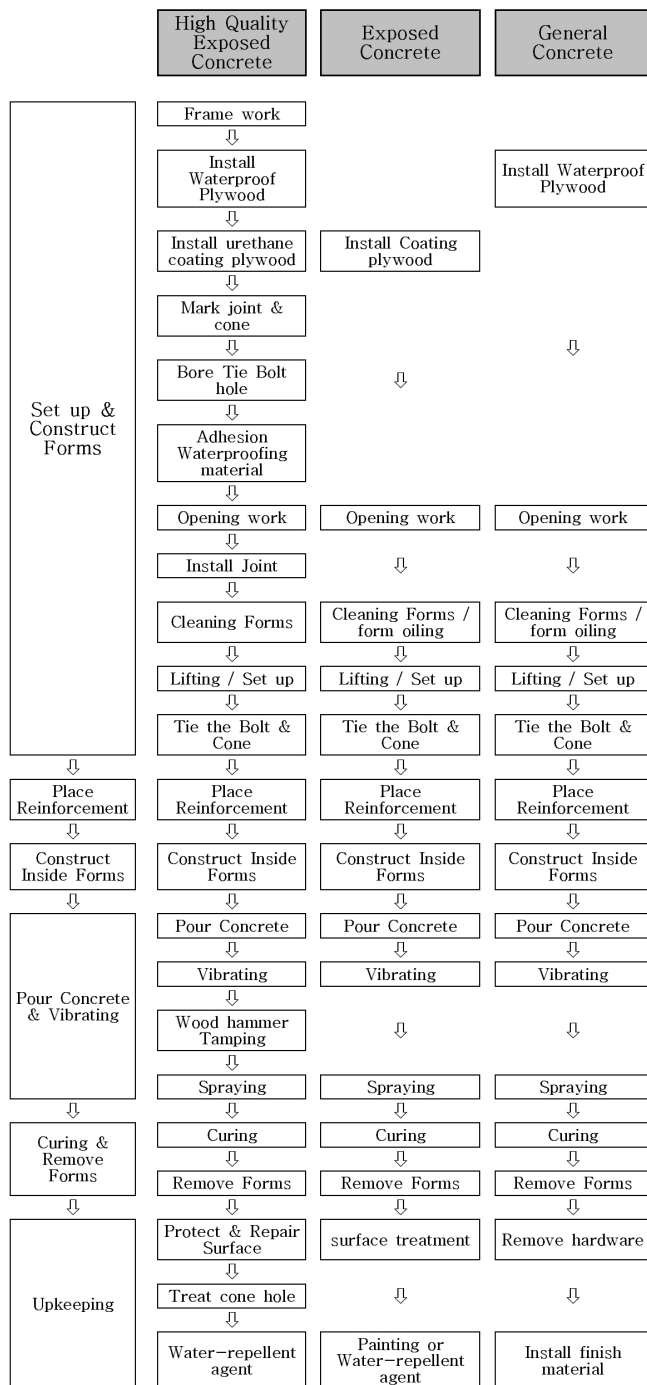


Figure 2. Execution process according to finish

(3) Consideration on Different Material Connection

As the connection of different material also has different expansion and contraction coefficient from high quality exposed concrete, so crack is easily be occurred. to solve this problem, crack induction joint and expansion joint must be exercised.

Checklist for constructability review on design development phase is as Table 5.

**Table 5.** Checklist for Constructability Review at the Design Development Phase

Examine steps	Examine Point	Examine Branch				
		Work ability	Color Equality	Crack Restraint	Filling efficiency	Durability
examine elevation division	Surface division considering plywood size	●				
	Tie Interval considering Lateral pressure	●				
	Construction joint considering once quantity of concreting		●		●	●
	Avoid complicated shape considering concreting				●	
	Crack induction joint considering Shrinkage crack			●		●
Elevation. Section	Considering relation joint & cone with opening	●				
	Considering relation joint & cone with slab & girder	●				
	Similarity of Height Elevation	●				
	Parapet Shape			●		
	Creasing, Lintel		●	●		●
	Protrude Shape			●	●	
etc	increase thickness of cover concrete	●				●
	detail drawing for different material connection	●		●		●

**4.4 Construction Document Phase**

(1) Construction Document

High quality exposed concrete quality standard must be clear and on construction document use the terms consistently, and it should be reflected. Itemized statement, specification & execution scheme drawing. Waterproofed design should be done at construction document and increase thickness of cover concrete. Planning crack induction joint considering shrinkage crack. Especially, some preventive measure of crack should be taken for protrude shape, creasing, lintel, connection of other material .

(2) Itemized Statement

To calculate the net cost of construction in consideration of material cost, labor cost and other expenses of high quality exposed concrete. Additional cost about design & specific on construction and productivity should be calculated. Especially, the mold of high quality exposed

concrete is used less than that of general concrete, and has less productivity, so it should be also reflected on calculation of the cost.

(3) Specification & Execution Scheme Drawing

To get high quality surface, execution method, which can meet requirements, should be written specifically. Above all, specification of additional work for specification and execution scheme, which is added at construction process comparing other finish, should be presented. For example, water proofing and prevention of bend at form work, vibrating to prevent honey comb at pouring concrete, joint and cone hole and water-repellent agent at upkeeping.

**5. CONCLUSION**

This report is to do design management for constructability review of high quality exposed concrete, which is used increasingly in recent. To secure systematic management at design phase, we reviewed each definition and work at each design phase, We define high quality exposed concrete, a part of architectural concrete, as "an exposed concrete which has well ordered joint & is in pursuit of smooth surface." We reviewed requirements and influential factor to obtain high quality finishing surface and compared construction process of high quality exposed concrete with that of other finishing method. Management method at each design phase for constructability review to meet additional works and requirements is presented.

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