

# DESIGN FOR INFRASTRUCTURE SERVICE LIFE

# INTRODUCTION

- Process flows from design to construction, maintenance and rehabilitation
- For infrastructure to function effectively, it must start with a good design
- Design of pavements, buildings, bridges – theoretical design vs empirical design
- Design is often practiced in a deterministic way – a specific design can be defined that uniquely fits a set of physical circumstances
- Approach is inadequate – variability in the input parameters
- Need is a reliability based design

# DESIGN TECHNOLOGY FRAMEWORK

- Design has to be comprehensive
- Design has often been compartmentalized
- Water pipe design / sewer design – process of sizing the pipe or flow; should also include the selection of material, optimal location
- Design of pavement – selection of layer thickness, materials, loads, SN
- Bridge – RCC, PSC, steel
- Design Is The First Cost Related Element Of Infrastructure Management
- Good economical optimum design is critical to any effective infrastructure management
- Description of most design practices (see flow chart)

# FACILITY OBJECTIVES

- Maximum or reasonable economy in terms of both agency and user costs
- Maximum or adequate safety
- Maximum or reasonable serviceability over the design period (performance)
- Maximum or adequate capacity for both the magnitude and number of repetitions of demand
- Minimum or limited physical deterioration due to environmental and use influence
- Minimum or limited noise and air pollution and environmental disturbances during construction
- Minimum or limited disruption of adjoining land or facility use
- Maximum or good aesthetics

# DESIGN REQUIREMENTS

- Specific objectives of the design process in terms of technical, social and economic terms
- Develop a design strategy of minimum (or reasonable) economy, safety and serviceability
- Consider all possible design alternative strategies
- Recognise and incorporate the variability in design factors
- Maximize the accuracy of predictions of serviceability, safety and physical deterioration for the alternatives considered
- Maximize the accuracy of estimating costs and benefits
- Minimise the cost of design including labour, testing and computing time
- Maximise information transfer and exchange between construction and maintenance personnel
- Maximise the use of locally available materials and labour in the considered design strategies

# DESIGN CONSTRAINTS

- Availability of time and funds for the design and construction
- Minimum level of serviceability allowed before rehabilitation
- Availability of materials
- Minimum and/or maximum dimensions allowed
- Minimum time between successive rehabilitations
- Capabilities of construction & maintenance personnel and equipment
- Testing capabilities
- Capabilities of structural and economic models available
- Quality and extent of design information available

# DESIGN PHASE

- Information needs related to input, objectives and constraints – Environment, load, traffic, material characteristics, Other factors – cost, estimated service life, inflation, interest rate; sensitivity analysis
- Analysis of structure, flow characteristics and other aspects of the facility
- Generation of alternate designs strategies – more than just thickness design; consideration of various material types and sources, expected construction, maintenance and performance evaluation policies, QC/QA methods
- Economic evaluation and optimization of the strategies

# EVALUATION CRITERIA

- To be established at the beginning of the design process, understood and accepted by all concerned
- The owner, designer and constructor have different interests and uses for a cost-effective design; designer – Completing the project on schedule, within budget and with high quality.

# INITIAL DESIGN EVALUATION CRITERIA

Criteria	Quantitative	Subjective
Accuracy of Design Documents	✓	
Usability of Design Documents		✓
Cost of Design Effort	✓	
Constructability of Design		✓
Economy of Design	✓	
Performance against schedule	✓	
Ease of Start-up	✓	

# OTHER CRITERIA

- Operatability
- Maintainability
- Safety
- Performance
- Accuracy of Design Documents: Accuracy of specifications and drawings
- Usability : Ease of use of design documents
- Cost of design effort: Cost effectiveness of the design activities compared to original budgeted amount and overall project costs

# OTHER CRITERIA

- Constructability ; Constructability is the optimal use of construction activity in planning, engineering, procurement and field operations
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- Economy of Design: Over design or inefficient design
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- Performance against schedule : Timeliness of design document and material delivery
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- Ease of Start-up: Planned to actual start-up time
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# CONSTRUCTION

- Construction converts design recommendation into a physical reality
- Successful construction meets the planning and design objectives within the budget and time constraints
- Changes in site conditions may warrant changes in design

# FOCUS

- Interrelationships of construction with other phases of infrastructure management
- Constructability of the project
- Construction quality assurance
- Documentation

# CONSTRUCTION DOCUMENTS

- Set of Drawings
- Project Specifications – Details of materials to be used, characteristics etc.,
- Standards and Specifications

# CONSTRUCTION MANAGEMENT

- Use of physical, financial and personnel resources to convert designs into physical reality
- Estimation
- Scheduling of activities
- Legal aspects
- Finances and Cost control
- Records

# CONSTRUCTABILITY

- Expediency with which the facility can be constructed.
- Project Owner – Lower cost, shorter schedule, improved quality
- Designer – Understanding the methods and constraints of actual construction required to execute the design being made
- Contractor – Opportunities to minimize the efforts and resource expenditure

# TYPE OF SPECIFICATIONS

- Methods and Materials Specifications
- Recipe Specifications
- End-Result or End-Product Specifications
- Performance Based Specifications
- Guarantee or Warranty Specifications for a specified time or utilization period.
- Methods and Materials Specifications – Most common

# RECIPE SPECIFICATIONS

- Inclusion of certain ingredients or materials and requires that they be mixed, manufactured, installed or placed in a specified way
- Portland Cement Concrete – Aggregate type, gradation percentage, cement, water content, additives to improve workability and increase setting time, minimum acceptable strength
- Contractor is told everything to do in the process
- Liability exists if the recipe is faithfully followed using the specified materials, but does not meet the performance requirement. (GSB specifications example); Where does the fault lie??
- Legal Claims – Settlement in court/arbitration

# END RESULT SPECIFICATIONS

- Concentrates only on the final product
- End result specifications are accepted by the contractors and public agencies
- Determines the responsibility for product quality control and quality assurance
- Contractors produce high quality work
- Agency –Improved product; reduced life cycle cost
- Innovations can be introduced
- Issues: Standardisation of equipment for performance measurement, calibration of the equipment
- Realistic setting the end result specifications – should be attainable by a good contractor; not so low that any contractor can meet the specifications
- Introduction of a bonus clause as an reward for good works; experienced contractors can discount their bonus into the bid price

# PERFORMANCE BASED SPECIFICATIONS

- More complicated to develop and use than end-result specifications
- Write a specification for the contractor to provide a given level of performance
- Performance is a time-history function
- Performance based to performance related specifications
- Difficulty in constructing infrastructure facilities using new materials and observe the performance – long term process.
- Not possible to prescribe the performance based specifications because of the complexities involved.
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# GUARANTEE/WARRANTY SPECS.

- Lack of adequate experience
- Guarantee approach is better contracting and pricing mechanism than a direct warranty - Privatisation of infrastructure
- Warranty specs – No need to inspect, check and test the construction process on a day-to-day basis.
- Type of testing for recipe or performance based specs is not necessary
- Criteria – no of complaints – ride quality, water pressure etc. can be a criteria.
- Privatisation of Maintenance
  - Designation of an entire area or network of roads to be bid by a consortium
  - Consortium agrees to provide necessary maintenance, reconstruction and rehabilitation for a fixed period and to do everything necessary to provide the facility at an acceptable service level for the contract price.
  - Lowest bid need not be the winning bid – LoS and quality within groups may vary.

# PRIVATISATION OF NEW FACILITIES

- New facilities are easy to privatize
- Solicitation of offers – connect A to B – specify LoS expected viz., speed, capacity etc., - Turnkey facility for a monthly/annual cost basis.
- Overall effectiveness evaluation – greatest B/C ratio; not based on the lowest bid
- Successful bidders are not allowed to charge more than the bid tolls.
- Annual costs are fixed – difference between the collected tolls and the cost basis are borne by the owner.
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THANK YOU..