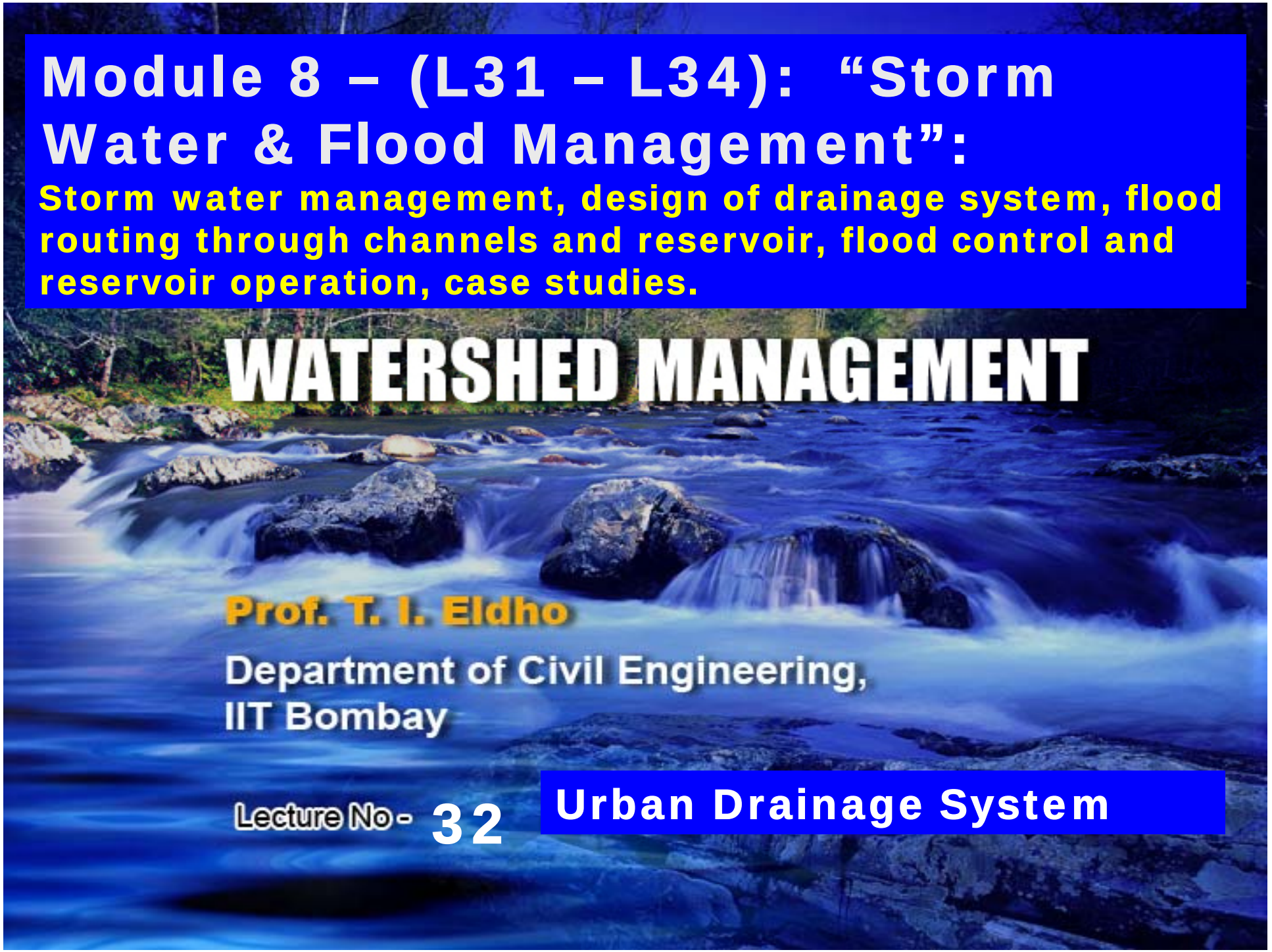
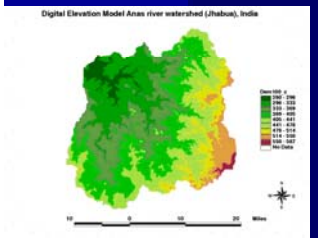
Module 8 – (L31 – L34): "Storm Water & Flood Management":

Storm water management, design of drainage system, flood routing through channels and reservoir, flood control and reservoir operation, case studies.



L32– Urban Drainage System

- **Topics Covered**
- Urban flooding, disaster risk management, Urban drainage system, design requirements, Roadside drainage design
- Keywords: Urban flooding, drainage system design, risk management, roadside drain.



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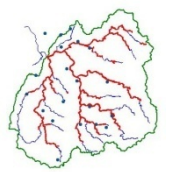


Causes of Urban Flooding

- Why urban flooding?. –
  - large increase in concrete/ impervious surface?.
  - Unplanned usage of urban land?.
  - Lack of proper drainage?.
  - Loss of wetlands?.
  - Less groundwater usage / recharge?.
  - Tidal effects?.
  - Very heavy storms – cloud burst?.

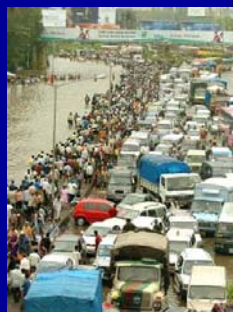
Mumbai on Jul 26, 27, 05

Urban Flood Disaster Risk Management

- Developing appropriate coping strategies & disaster risk reduction plans, along with greater awareness of how to reduce risks, is the high priority agenda
- Strategies: Enhancing national, state and local scale advocacy partnerships and knowledge management
- Standardizing hazard risk management tools, methodologies and practices
- Developing integrated and coordinated approaches
- Incorporating 'Learning by Doing' mode of operations
- Promoting the diffusion/documentation of best practices
- Building appropriate communication protocols facilitating multi-platform and multi-lingual dissemination

Urban Flood Disaster Risk Management

- Analyzing & presenting information in an easily understandable form, for wider use by decision makers,
- Encouraging integrated approaches of project implementation based on Master Plan,
- Encouraging states to accord top priority to deal with recurring urban flooding
- Urban flood management – difficulties
- Comprehensive risk assessment, Factoring risks in development planning, Coordination among different institutions, Lack of information sharing, Disintegrated investment decisions, Lack of consultation with stakeholders etc.



Watershed Based -Urban Flood Management

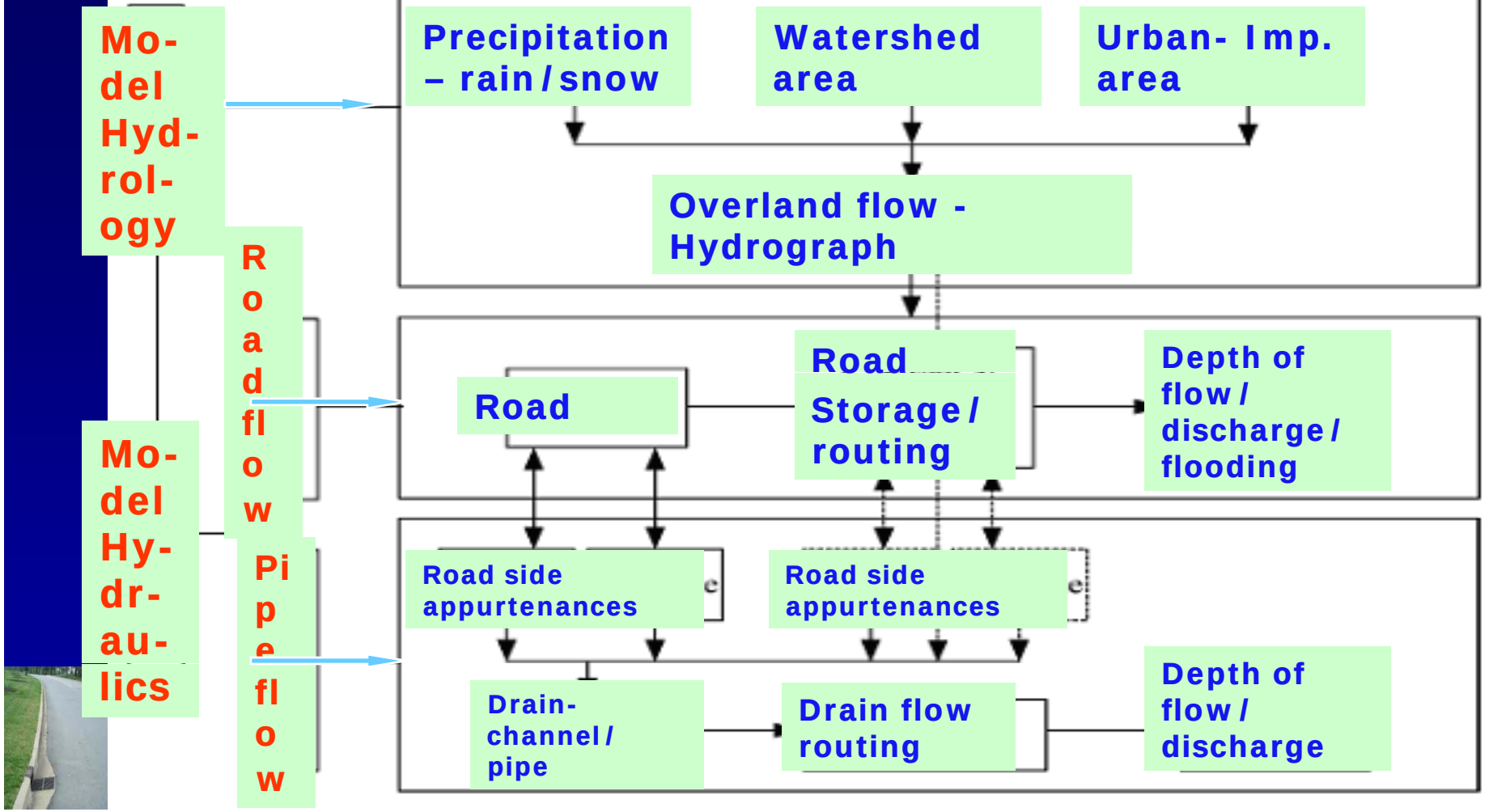
- Any planning for effective urban flood management has to take into the consideration of entire watershed.
- Identify problems, causes & remediation
- Preparedness and mitigation,
- Early warning and communication,
- Response,
- Awareness generation,
- Community capacity development.
- Vulnerability & risk assessment – reduce vulnerability
- Hazard mapping: flood level mapping, identify damages, insurance & risk transfer
- Spatial Decision Support System
- Urban Information System

Urban Drainage System

- Drainage systems categorized as major & minor systems.
- Major drainage system - comprises of open nallahs/ and natural surface drains, etc.
- Minor system - network of underground pipes & channels.
- Minor system categorized into two types: separate & combined.
- Separate drainage systems consist of two conveyance networks: sanitary sewers (usually underground pipes) conveying wastewater from homes & businesses to a discharge point, while the storm drains (underground pipes or channels) collect water from the rainfall runoff and convey it to a discharge point

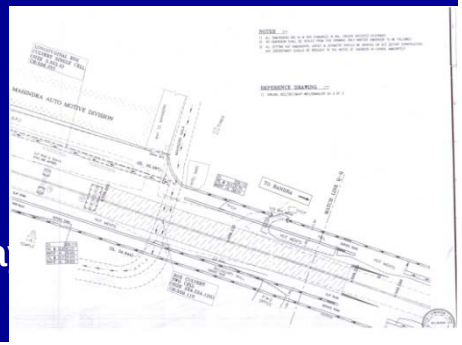
Urban Drainage - Processes

(Mark et al., 2004)



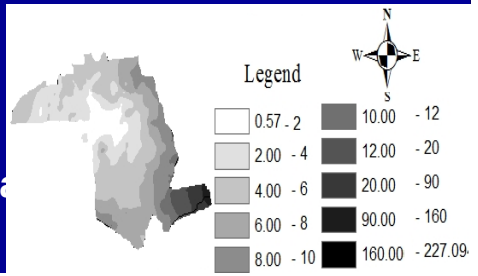
Stormwater Drainage System

- Total stormwater system – major & minor – inventory of the system for better management – GIS platform.
- Inventory will be both watershed based to enable proper hydrologic & hydraulic analysis & ward based to enable coordinated administrative management
- Minor systems should be mapped clearly showing the interconnections with major system besides the cross connections with sewer lines
- Major systems - be mapped clearly with delineation, demarcation & details of cross-sections, slopes, drain crossings including natural formations & man made structures



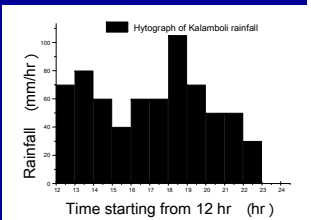
Urban Drainage Design - Requirements

- Development of an adequate & functioning drainage system based on sound hydrologic & hydraulic design principles.
- Design of an urban drainage system requires knowledge of the catchment area and topography, urbanization details, rainfall intensity, hydrology, hydraulics, etc.
- Watershed/ Catchment as basis of urban drainage design
- Contours are necessary for determining the boundaries of a watershed/ catchment & for computing directions of flow.



Urban Drainage Design - Requirements

- Rainfall data: For design of a drainage system, the conventional practice is to choose an appropriate, statistically relevant design storm to establish the stormwater flows to be conveyed, based on existing national & international practices.
- Design storms can be estimated from rainfall data records where available.
- Up to date IDF (Intensity Duration Frequency) relationships need to be used to maintain design standards for new systems & retrofitting/replacement of old urban drainage systems.
- IDF curves should be developed for each city, based on extraction of data from the raw data charts at min. 15-minutes resolution



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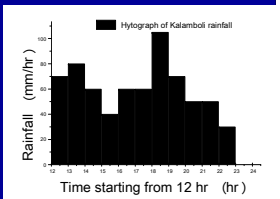
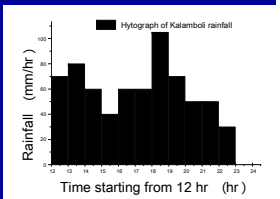
Urban Drainage Design Considerations

- Frequency of thunderstorms - additional consideration for planning future urban drainage systems.
- Design flow: To protect urban areas, safe management & passage of water, resulting from frequent storm events (hydrologic design aspects) & adequate capacity (hydraulic design aspects) must be considered.
- Urban Drainage Design: main objectives of hydrologic analysis & design are to estimate peak flow rates &/or flow hydrographs for the adequate sizing & design of conveyance & quantity control facilities
- To estimate peak flow rates, knowledge of the rainfall intensity, its duration & frequency is required



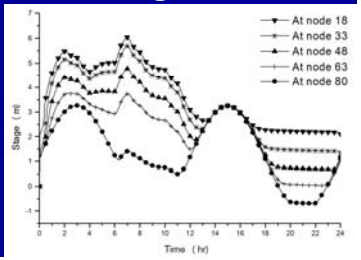
Urban Drainage Design-Problems

- Increasing rainfall intensities induced by climate change, urban heat islands and other factors, will possibly result in varying return periods for a given intensity of rainfall.
- Rainfall intensity to be used for design will also depend on the time of concentration.
- Higher the catchment area, higher will be the time of concentration & lower will be the design rainfall intensity, other factors remaining the same.
- Peak flow rates can be estimated using Rational Method $Q = C\ I\ A$.
- Approximations based on run-off coefficient, rainfall intensity & area of catchment.



Design Considerations

- Simple channel design: Manning's equation: $Q = AR^{2/3}S^{1/2}/n$
- For computation of water level profiles in the drainage systems or channels/rivers, suitable software for flood routing should be used.
- Public domain software - HEC-HMS for hydrologic modelling of the watershed, HEC-RAS for river modeling, SWMM (Stormwater Management Model) for sewer/ drainage design
- All future stormwater drainage systems may be designed taking into consideration a runoff coefficient of upto C = 0.95 for estimating peak discharge using the rational method



UDS – Operation & Maintenance

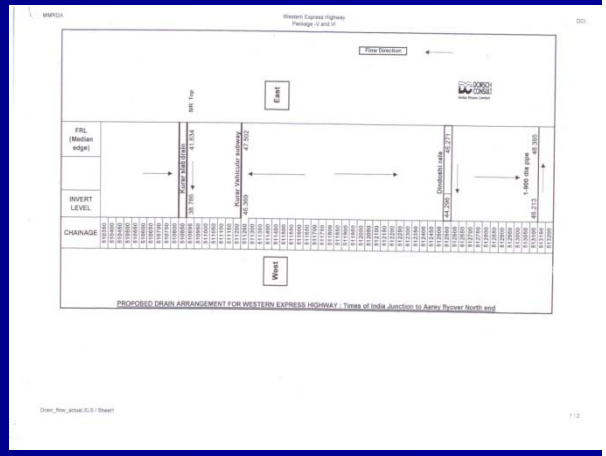
- Proper operations and maintenance (O&M) are crucial for any system to be functional to the designed capacity & for its durability as well.
- Pre-monsoon desilting -a major O&M activity.
- Periodicity of cleaning of drains should be worked out, based on the local conditions.
- Removal solid waste: Suitable interventions in the drainage system like traps, trash racks can reduce the amount of solid waste going into the storm sewers
- Removal of sediment
- Drain inlet connectivity

UDS – Special Considerations

- Low-lying areas should be reserved for parks and other low-impact human activities,
- Wherever unavoidable, buildings in low lying areas should be constructed on stilts above the High Flood Level (HFL)/ Full Tank Level (FTL)
- For chronic flooding spots, alternate locations may be explored for accommodating people staying there
- Buildings should be constructed on stilts after taking into account the stability of slopes, and
- Stormwater drainage systems for coastal cities have to be designed taking into account the tidal variations.

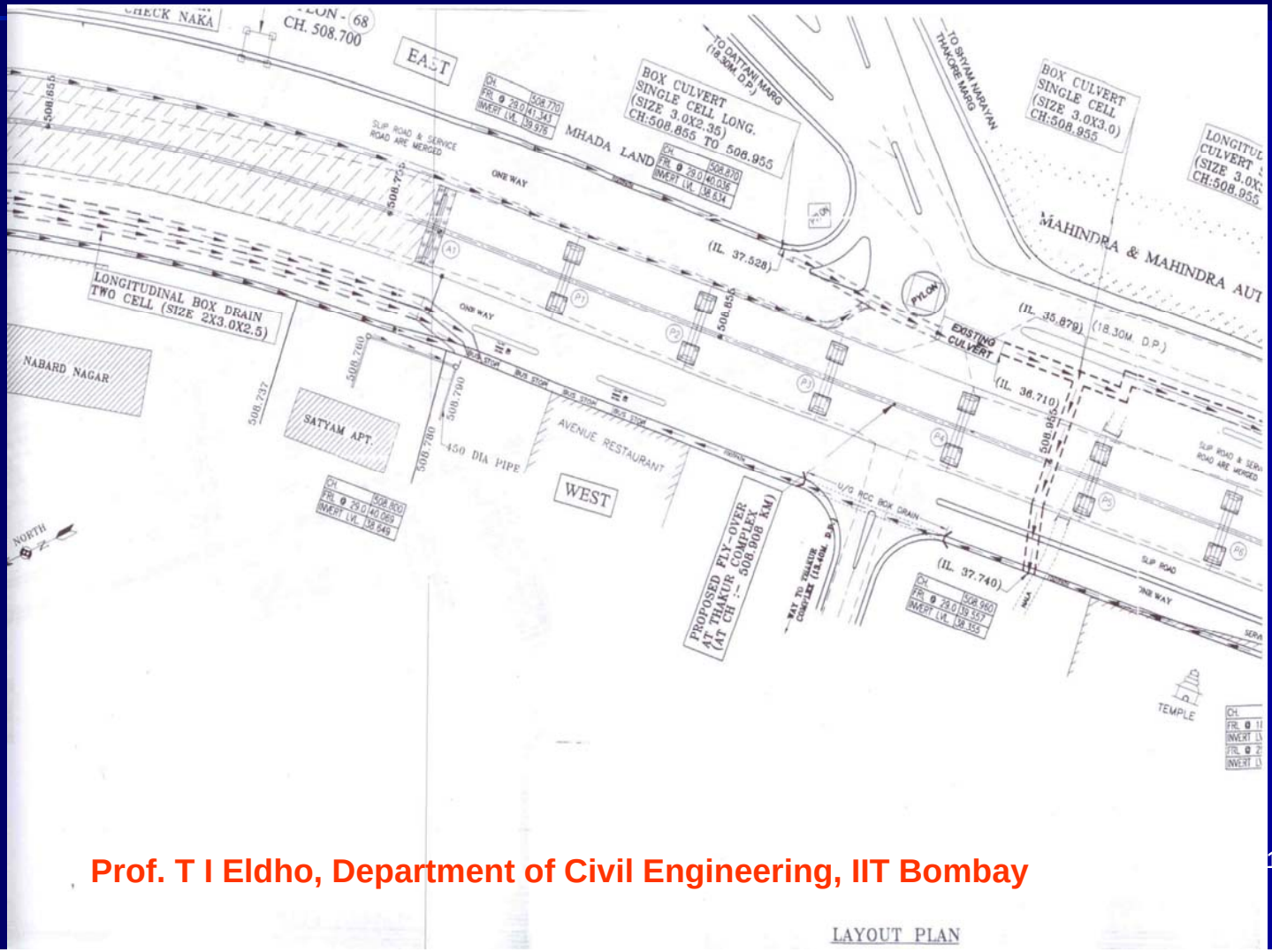
Road Side Drainage

- Road side drain: Integral part of urban drainage system
  - **Storm Drainage**
    - Collect storm water runoff
      - Away from structures
        - Through roadway and/ waterway
        - Right-of-way



- Objectives
  - Appropriate design – Hydrologic & hydraulic considerations
  - Minimize the flooding and erosion to properties
  - Safe traffic

Road Side Drainage – Design



Road Side Drainage – Design Steps

- Design Problem and design criteria specification
  - Type, specific locality
- System drainage area definition and preliminary layout
  - Street layout, total drainage area to be handled
- Field and office data collection
  - Make field visit, site specific problems (no width, trees, outcrops, utility locations, etc.
- System layout
  - Final layout, all ditches, waterways, inlets, manholes, mains, laterals, culverts, flow direction, etc.

Road Side Drainage – Design Steps

- Hydrologic calculations
  - Flow estimation for the designed frequency
- Street flow
  - Flow and spread calculations, maximum spread, gutters flow
- Inlet spacing and layout
  - Location and type of inlet, size, extra inlet, etc.
- Hydraulic calculations
  - Size of the drain, permissible velocity, slopes, etc.
- Various design checks
  - Discharge, Froude number, velocity, slope

Drainage Design - Factors

- Return period of flood (rainfall)
- Spread
- Inlet types and spacing
- Longitudinal slope; Cross slope
- Curb and gutter section
- Roadside and median channels
- Bridge decks / fly over
- Shoulder gutter
- Median barriers
- Storm drains
- Detention storage; Erosion
- Cost

www.greenhighwayspartnership.org

Important Design Considerations

1. How much area should be considered for a reach?

- Actual length is in-between hydrologic mount to draining point

2. How much width should be considered on other side of the road drainage?

- Internationally road side drain are designed to cater “only road run-off”, but in highly populated area it may be designed to carry run-off from near-by area also

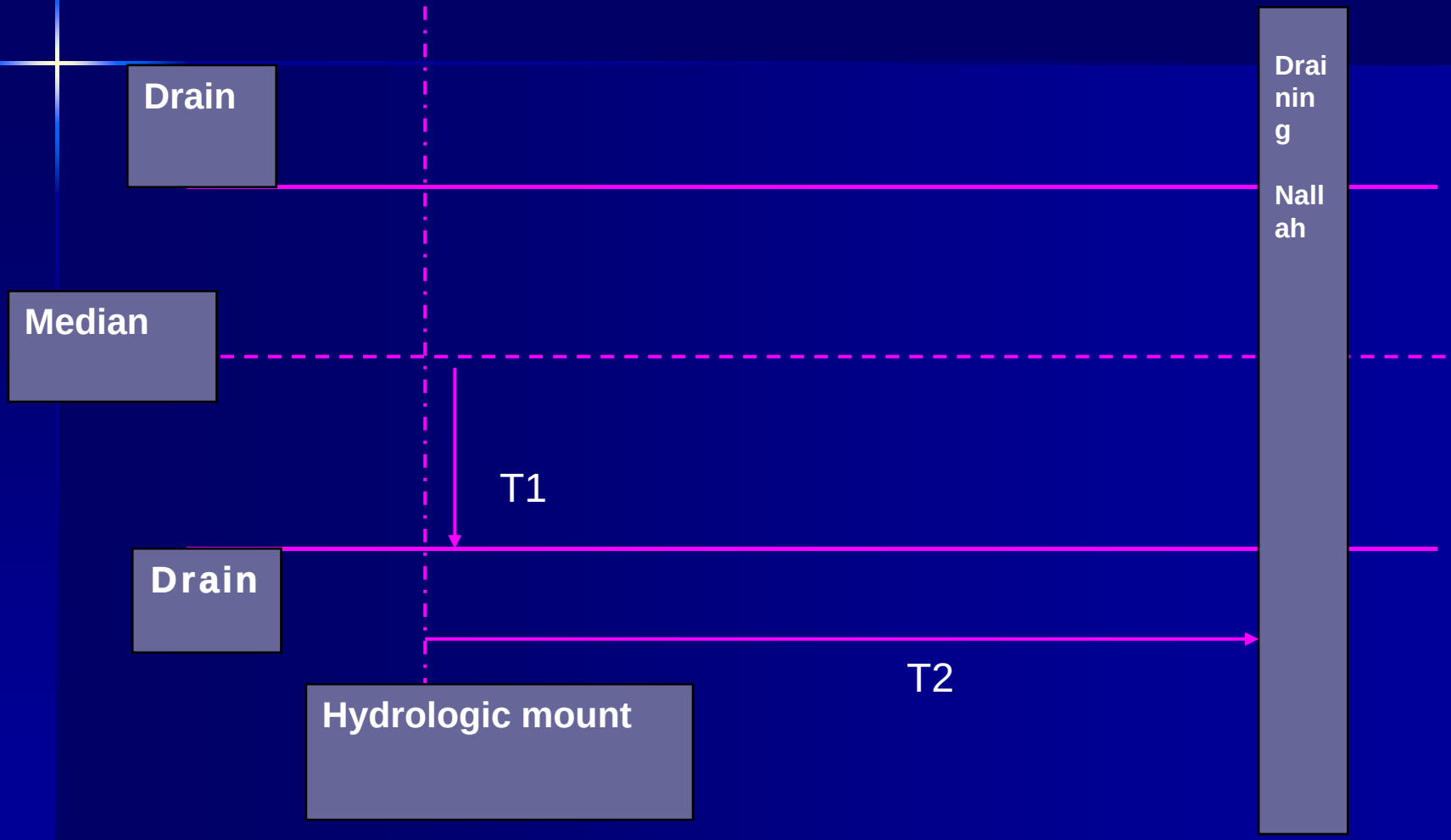
Important Design Considerations

- Actual width should be based on topographical survey
  - The roads in Mumbai are very peculiar
  - The actual area contributing to road side drain is not known

3) Designed rainfall intensity?

- Generally rainfall intensity with 10 year return period
- For important roads it should be 50 year return period
  - It should be based on time of concentration, IDF curves
  - IRC recommends time of concentration as: made of two time periods: 1.Time required for the rain water to flow over the road surface and enter into the drain (T1); 2. Time of flow in drains (T2)

Time of concentration = T1+T2



Important Design Considerations

- As per IRC 50: For Mumbai the critical intensity of rainfall is 50 mm/hr
- The values are worked out assuming
  - Time of concentration of 30 mints
  - Rate of rainfall is 62.5 mm/hr (return period 2 years)

4) Average runoff coefficient (C) of 0.6

Type of surface	Range of C
Bituminous and cement concrete pavement	0.8- 0.9
Gravel and WBM pavement	0.35-0.70
Impervious soil	0.40-0.65
Soil covered with turf	0.30-0.55
Pervious soil	0.05-0.30

Important Design Considerations

5) Manning's Coefficient value?

- For concrete channels it is 0.013 to 0.017

6) Permissible velocity in the drains?

- For RCC drains - allowable is 6 m/s but practically it was restricted 3 m/s.

Surface Characteristics	Range of n
Concrete:	
a) Formed, no finish	0.013 to 0.017
b) Trowel finish	0.011 to 0.015
c) Float finish	0.013 to 0.015
d) Gunite, good section	0.016 to 0.019
e) Gunite, wavy section	0.018 to 0.022

Important Design Considerations

7) Width and depth?

- The width is as per the local width available for the construction of the drains
- Depth should be estimated based on Manning's formula
- As far as possible rectangular
- Economical section is b=2d
- Some places pipes were also used

AS per IRC 50: Minimum width of drain should not be less than 250 mm and incase of pipe the minimum diameter should not be less than 450 mm.

Important Design Considerations

8. Slope of the drains? Longitudinal slope?

- Generally slope should not be less than 0.3%
- But in flat terrain it can go upto 0.2%
- Slope is designed such that the flow is always in sub-critical flow
  - To avoid hydraulic jump
    - **As per IRC 50, a minimum longitudinal gradient is 0.3%**

Important Design Considerations

9. Free board?

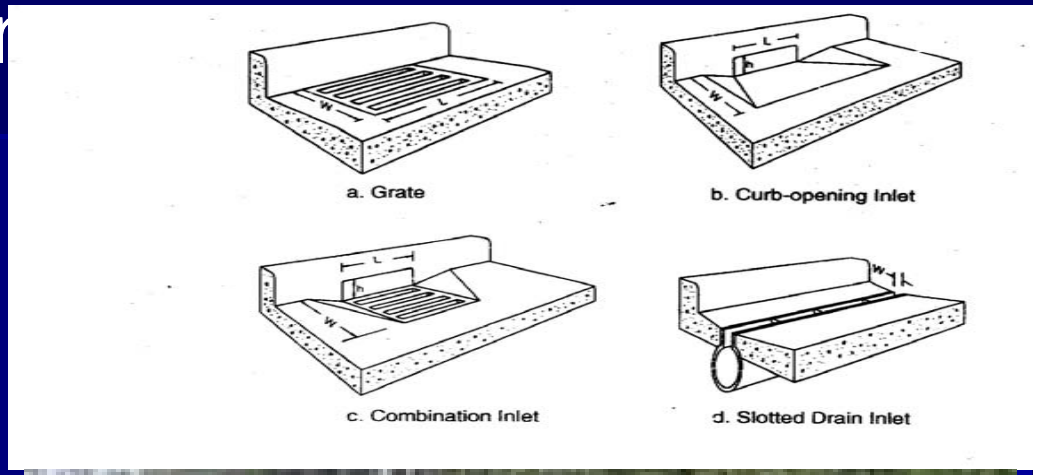
- Generally for open channels a free board of 0.3 m is provided
- But Mumbai is having very flat terrain and does not allow to have more free board.

- IRC recommends the following free boards

Bed width	Free board
< 300 mm	10 cm
300 to 900 mm	15 cm
900 to 1500 mm	30 cm
Larger size	90 cm

Design Consideration

10. Type of inlet to drains?
- Curb inlet
  - Grate
  - Combined



Design Considerations

11. Junction box size?

- This should be designed as per the velocity of the water crossing or joining each other.

12. Adequacy of nallah

Level difference between IL and Maximum Water level in nallah

- If the Inverted Level of the drain is lower than the MWL in nallah then nallah water starts entering into the drains
  - Then slope has to be modified and designed such that the IL of drains is above the MWL of nallah.

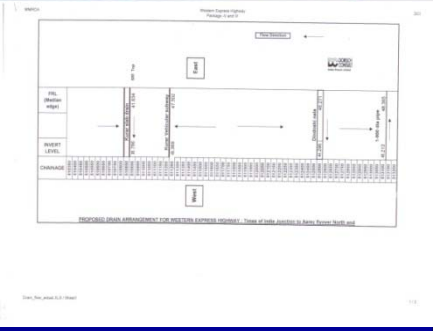
13. Connection between the Main drain on either side of the road

Design Considerations

14) Design of drain draining to the creek or nallah having tidal effect.

- If the outlet point of the drain is to a creek or a nallah whose water level rises according to the tide level
- The IL of the drains should be above the high tide level, else sea water enters the drain
- If possible a large size drains may be constructed which can act as holding pong until the high tide level.

Data Needed for the design



- I Rainfall intensity
- Runoff coefficient
- Area contributing to drains (length and width)
- Cross-sectional parameters of the road
- RL of the hydraulic mount
- RL of the ground level, IL of the drains

II. KEY PLAN OF THE WORK

the length

location of nallah

size, IL of drains at starting point and draining point

Slope between the sections

Other major drainage work nearby/ or river nearby

Data Needed for the design

III. DETAILED PLAN OF THE ROAD

- Length (in terms of chainage)
- Location of point sources and their discharge
- Hydrologic mount
- RL of ground levels at chainage points and other important points
- Arrows showing the flow direction of storm water in the drains
- Location of draining nallah
- Location and size of cross drainage work
- Location of man holes and their sizes
- Any other item relevant to the site specifi be highlighted)

Data Needed for the design

IV. LONGITUDINAL SECTION DRAWING

- Finished Road Level
- RL of existing ground level
- IL of drains
- Bed levels, water levels of nallah
- Location of curb inlet points
- Location and size of other point sources joining the drain

References

- American Society of Civil Engineers and Water Environment Federation (ASCE and WEF). 1998. *Urban Runoff Quality Management.* WEF Manual of Practice No. 23, ASCE Manual and Report on Engineering Practice No. 87.
- *http://ndma.gov.in/ndma/guidelines.html*
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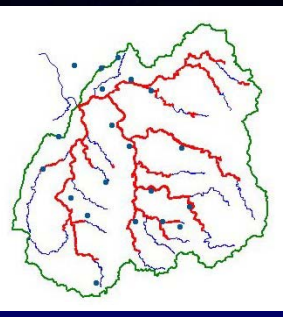
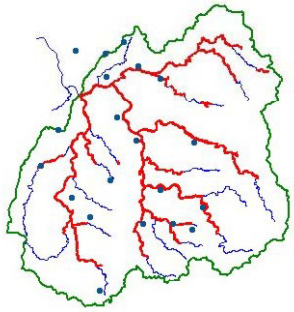


Tutorials - Question!.?.

- Critically study the urban drainage design methodology adopted in India?.

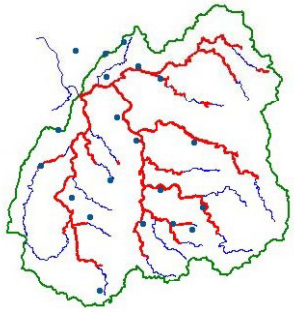
  http://ndma.gov.in/ndma/guidelines.html

- Compare the urban drainage design practices in USA, UK and India and propose better management practices for Indian Cities.



Self Evaluation - Questions!.

- What are the important causes of urban flooding?
- What are the difficulties in urban flood management?
- Discuss watershed based urban flood management.
- Describe the inventories to be taken for stormwater drainage system.
- What are the important design considerations for urban drainage systems?.
- What are the important data to be considered for roadside drainage design?.



Assignment- Questions?.

- What are the important strategies for urban flood disaster risk management?.
- Illustrate various urban drainage systems.
- What are the important design requirements for urban drainage systems?.
- Discuss the important design considerations for roadside drainage design?.
- What are the important factors to be considered for roadside drainage design?.

THANK YOU

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