“SUSTAINABLE TECHNOLOGICAL SOLUTIONS FOR FASTER AND COST EFFECTIVE CONSTRUCTION OF MASS HOUSING”

AP HRDI- Residential Training Programme on "Pradhan Mantri Awas Yojana (PMAY) - Housing For All (HFA)"

Anupam Mittal

Vijaywada | 22 September 2017
Pradhan Mantri Awas Yojana
Housing for All (Urban)
Hon’ble Prime Minister envisioned Housing for All by 2022 when the Nation completes 75 years of its Independence. launched a comprehensive mission “Pradhan Mantri Awas Yojana – Housing for All (Urban)".

Due to the large volume of housing to be undertaken in both urban and rural areas with limited availability of building materials and finance available, it is important that proven/green and faster construction systems are used, with due care for structural and performance requirement.

The Technology (Monolithic Concrete Construction)

The construction in which all the elements are cast together with RCC by using Aluminum formwork/similar form work, which supports wall, beam, column, roof slab and other elements together for concreting in one go. Cost effective and Time saving.
<table>
<thead>
<tr>
<th>State</th>
<th>No. of towns and cities</th>
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<td>0.17%</td>
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<td>0.14%</td>
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<td>0.13%</td>
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<td>0.10%</td>
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<tr>
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<td>8</td>
<td>147,695</td>
<td>0.05%</td>
</tr>
<tr>
<td>D&amp;N Haveli</td>
<td>1</td>
<td>98,265</td>
<td>0.03%</td>
</tr>
<tr>
<td>Daman &amp; Diu</td>
<td>2</td>
<td>68,273</td>
<td>0.02%</td>
</tr>
<tr>
<td>A&amp;N Islands</td>
<td>1</td>
<td>14,172</td>
<td>0.005%</td>
</tr>
</tbody>
</table>

**THE NEED**

**Andhra Pradesh** as FOCUS state under PMAY.
Despite an urban population of more than 1.14 cr, Uttar Pradesh is building only 195,022 houses under PMAY.

Nearly 11.04% of the involved houses

THE NEED

PRESENT STATUS

The need for correct housing requirement for Uttar Pradesh must be worked out, for proper utilization of resources provided by the central govt.

17,73,052 Houses involved all over India in first Phase

<table>
<thead>
<tr>
<th>State</th>
<th>No. of towns and cities</th>
<th>No. of DU's proposed in phase I</th>
<th>Percentage</th>
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<td>628</td>
<td>20,467</td>
<td>1.16%</td>
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<tr>
<td>Tamil Nadu</td>
<td>667</td>
<td>227,700</td>
<td>12.89%</td>
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<td>171</td>
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<td>144,337</td>
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<td>379</td>
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<td>82,949</td>
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<td>195,022</td>
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<tr>
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<td>48</td>
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<tr>
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<tr>
<td>Sikkim</td>
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<td>1</td>
<td>0.00%</td>
</tr>
<tr>
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<td>828</td>
<td>0.05%</td>
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<td>48</td>
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**Total** | 299,462,980 | 100% | 20,000,000 | 4,000,000

About 761500 Units to be constructed in next 5 Years

152300 units / Year

**How to Do It?**

Technology
The vision of PMAY could only be possible by adapting to change, to grow along with time, moving from conventional to advanced technologies.
GOVERNMENT NOTIFICATIONS

Adoption of New & Emerging Technologies in construction work of value not less than Rs. 100 crores.

- Monolithic Concrete Construction System using Aluminium Formwork.
- Industrialized 3-S system using cellular light weight concrete slabs & precast Columns (Precast / prefab)
- Monolithic Concrete Construction System using Plastic - Aluminium Formwork.

Undertaken by:- CPWD, DDA and NBCC etc.

Office Memorandum By MOUD on Date 30/05/2016
Office Memorandum By MOUD on Date 28/12/2016
Dear Shil,

Urban areas are engines of the growth of the country’s economy. Urbanisation is increasing at a fast pace in India also. Presently 31% population lives in urban areas, which is expected to increase to 40% by 2050. Fast paced urbanisation requires commensurate availability of housing. As per the Technical Group report of this Ministry there is shortage of 18.78 million dwelling units (in 2012) in urban areas. 95% of it pertains to low-income segment. Urban poor needs to be provided affordable housing by State/Central Government through schemes/programmes along with involvement of private sector. Technology can play a big role in mass construction, which are not only aesthetically and functionally good, but are structurally sound and environmentally sustainable also.

Building Material and Technology Promotion Council (BMTPC), an autonomous organisation under the Ministry is making efforts to promote emerging affordable housing technologies for mass construction. After extensive study of technical specifications on performance characteristics, a few technologies for mass scale housing have been recommended by BMTPC as per annexure attached. I understand some States have already started adopting some of these emerging technologies for mass housing projects.

Suitability of these technologies for mass housing projects in your State may be examined.

With regards,

Yours sincerely,

[M.Venkiah Naidu]

End: As above

Office: Room No. 104-G, Nirman Bhavan, New Delhi (110001). Phone: 011-23091164, 23091162, 23091169 (Fax)
Residence: 32, Ashtapada Road, West Delhi - 110014. Phone: 011-28291087, 28291086 (Fax)

Ministry of Housing and Urban Poverty Alleviation

& BMTPC Recommendations for Mass Housing

Technologies recommended by BMTPC for Mass Housing

1. Technology Profile of Monolithic Concrete Construction System using Plastic-Aluminium Formwork.
2. Technology Profile of Monolithic Concrete Construction System using Aluminium Formwork.
3. Technology Profile of Expanded Polystyrene Core Panel System
4. Technology Profile of Industrialized 3-S System using Cellular Light Weight Concrete Slabs & Precast Columns
5. Factory made Fast Track Modular Building System-INSTACON
6. Glass Fibre Reinforced Gypsum Panel System
7. Formwork for Monolithic Construction.
8. Advanced Building System EMMEDUE.

Note: The details of above mentioned Technologies for Mass Scale Housing Projects may be downloaded from Building Materials & Technology Promotion Council (BMTPC) Website, i.e. www.bmtpc.org with a link http://www.bmtpc.org/LatestTopicsDetails.aspx?mid=54

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Tenders done in recent Past

ON

RCC MONOLITHIC TECHNOLOGY

1. Name of Work: Construction of Low Cost Housing for Urban Poor/Slum Rehabilitation at Tinni Kalan, Delhi. Comprising of 842 DDUs (G+4) in Phase-1 (SH: Cio 3380 DUs(G+4)) (Package-II).
3. Project Duration : 12 months
4. Estimated Cost: Rs. 156.00 cr. for 3380 DUs.
5. Technology for Housing: RCC Monolithic Technology for housing.

6. Tender called on Lumpsum basis (building works).
7. For items and works involving monolithic construction (Shear Wall) technology, the specifications and guidelines of CBRI and BMTPC shall be followed. In case, any ambiguity in interpretation of specification for such items of monolithic construction (Shear Wall) technology, the decision of the Engineer-in-Charge shall be final.
8. The agency may be asked to construct a sample dwelling unit in all respect on priority basis by the Engineer-in-Charge (i.e. including all fittings and fixtures)
9. Criteria of eligibility for submission of bid document: As per tender eligibility criteria for applying for tender/bidding are as follows related to executed similar works in last 7 years:
   • Bidder should have completed three similar works each costing not less than the amount equal to 40% of the estimated cost put to tender or two similar completed works each costing not less than the amount equal to 60% of the estimated cost put to tender or one similar completed work of aggregate cost not less than the amount equal to 60% of the estimated cost.
   • For un-registered firm, one completed work of any nature (Either part of above or a separate one) costing not less than the amount equal to 40% of the estimated cost put to tender with some Central Government Department / State Government Department / Central Autonomous Body /Central Public Sector Undertaking. The executed work shall mean that the tenderer has been paid by the Central & State Government Department / Central Autonomous Body /Central Public Sector Undertaking amount for completion/part
10. Tender called on Percentage basis.

6. Criteria of eligibility for submission of bid document: As per tender eligibility criteria for applying for tender/bidding are as follows:
   • Bidder should have completed three similar works each costing not less than the amount equal to 40% of the estimated cost put to tender or two similar completed works each costing not less than the amount equal to 60% of the estimated cost put to tender or one similar completed work of aggregate cost not less than the amount equal to 60% of the estimated cost.
   • One completed work of any nature (Either part of above or a separate one) costing not less than the amount equal to 40% of the estimated cost put to tender with some Central autonomous body/central public sector undertaking/ Central Government Departmental State Government Departments
11. For Housing projects, similar works could be regarded as having successfully completed. Multi storied housing projects and/or Institutional buildings and/or
## OUR CONTRIBUTION IN AFFORDABLE HOUSING

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Project</th>
<th>Location</th>
<th>Client</th>
<th>Dwelling Units</th>
<th>Built up Area</th>
<th>Approx. Cost in Cr.(INR)</th>
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<td>Lucknow Development Authority</td>
<td>9232</td>
<td>295424</td>
<td>500</td>
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<tr>
<td>2</td>
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<td>8420</td>
<td>305239.96</td>
<td>485</td>
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<tr>
<td>3</td>
<td>Sapna &amp; Aasra Enclave</td>
<td>Ghaziabad</td>
<td>U.P. Housing and Development Board</td>
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<tr>
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<td>70 District Of U.P.</td>
<td>U.P. State Govt.</td>
<td>4512</td>
<td>144384</td>
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<tr>
<td>5</td>
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THE EMERGING TECHNOLOGIES

1. **Monolithic Concrete Construction Technology (Suitable for Low Rise to High Rise Structures)**
   Also called Rapid Monolithic Disaster Resistant Construction (RMDC)
   In this system, in place of traditional RCC framed construction of columns and beams; all walls, floors, slabs, columns, beams, stairs, together with door and window openings are cast-in-place monolithically using appropriate grade of concrete in one operation with Aluminum Shuttering.

2. **Precast Concrete Construction Systems (Suitable for Low Rise to High Rise Structures)**
   Precast Large Construction Panel (PLCP) system consists of various precast elements such as walls, beams, slabs, columns, staircase, landing and some customized elements that are standardized and designed for stability, durability and structural integrity of the building.

3. **Rapid Panel System - EPS Core Technology (Suitable for Low Rise to Medium Rise Structures)**
   The Rapid Panel is a prefabricated assembly of high-strength steel wire forming a panel with a core of expanded polystyrene (EPS). During construction, Rapid Panels are installed as walls and/or slabs. Specified mixtures of mortar or concrete are applied to the surfaces of the panels to complete the structure.

4. **Light Gauge Steel Structure System (Suitable for Low Rise to Medium Rise Structures)**
   It is based on factory made galvanized light gauge steel components, designed as per codal requirements. The system is produced by cold forming method and assembled as panels at site forming structural steel framework of a building of varying sizes of wall and floor.

5. **Steel Structure (Suitable for Low Rise to High Rise Structures)**
   Factory Made Fast Track Modular Building System comprises of prefabricated steel structure with different walling components. About 70 percent of the work is done in the factory with minimal usage of concrete, which enables system to deliver the building within a few days of work at site. The steel moduled are pre-fitted with flooring, ceiling tiles, electrical and plumbing fittings.
WHAT IS R.M.D.C.?

(RAPID MONOLITHIC DISASTER-RESISTANT CONSTRUCTION)
THE TECHNOLOGY

WHAT IS R.M.D.C.?

The construction in which all the elements are cast together with RCC by using Aluminum formwork/similar formwork, which supports wall, beam, column, roof slab and other elements together for concreting in one go.

RAPID CONSTRUCTION

BEST QUALITY

COST MANAGEMENT

PRE-ENGINEERED DRAWINGS

LOW MAINTENANCE

TIMELY COMPLETION

COMPETITIVE PRICE

EARTH-QUAKE RESISTANT

RESOURCE OPTIMIZATION

GREEN BUILDING

WASTE REDUCTION

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Earlier, The monolithic construction was limited to special structures like domes, huge shell roofs, architectural elements and large footings for foundation etc, where, the structures had no joints. Performance and durability thereof were of utmost importance. Similar practices were never practiced for housing may be due to lesser advancement in form-work and concrete technology for mass construction.
India has about **26 million** dwelling units shortage, which is likely to escalate in coming years. To meet this huge requirement, Rapid, Durable, maintenance free and cost effective technology is needed. **RMD Technology** ideally meets this requirement.

The paradox is that, we are often amazed at the progress our country has made, when we see an **auto-rickshaw driver** with a **mobile** phone but, we fail to notice that he is still **living in a slum-like dwelling unit**.
TECHNOLOGY PROFILE OF R.M.D. TECHNOLOGY USING ALUMINIUM FORMWORK
### THE TECHNOLOGY

<table>
<thead>
<tr>
<th>Basic Material Requirements</th>
<th>Formwork system</th>
<th>Concrete</th>
<th>Reinforcement</th>
</tr>
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<td>Formwork system is propriety system and designed as per loading requirements of the structure. It should have adequate stiffness to weight ratio, yielding minimum deflection under concrete loading. The panel should fix precisely, securely and require no bracing. IS 14687:1999 Guidelines for falsework for concrete does not cover requirements by special type of formwork system.</td>
<td>Shall be of appropriate grade based on environment condition as per IS 456:2000</td>
<td>Shall conform to IS 1786:2008</td>
<td></td>
</tr>
</tbody>
</table>

### Details of Formwork

The formwork systems used are made of light weight Aluminum. The recommended concrete forms generally use robotics welding system for manufacturing. A soft alloy weld wire is utilized in the concrete form weld process. Fixing of the formwork is done using tie, pin & wedges system. Does not require very skilled labour to do the job. The formwork can be designed based on requirements of dwelling unit and the project. A repetition of about 1000 cycle is claimed (This, however, needs, verification).

**Self compacting concrete (SCC)** of suitable grade as per mix design and structural requirements is used for concreting. The inherent property of SCC is self compaction without segregation. Hence, SCC is more suitable for this technology. Free flow of concrete is maintained to be **600mm minimum**, during the pour, to ensure the proper flow and compaction.
### Structural Requirements of the Construction

The Monolithic Concrete Construction is considered as shear wall type construction. The maximum spacing between cross wall shall be limited to 1.5 times the floor height if supported on two edges and 2.0 times the floor height, when supported on all four walls. Walls are designed for vertical loading, in plane shear loading and out of plane loading due to wind load and earthquake forces as per relevant Indian Standard Code IS 875(Pt.3):1987 and IS1893(Pt.1):2002 respectively. For out of plane loading the wall can be assumed to be supported by floor slabs / diaphragm and cross walls and continuity can be assumed, wherever applicable. The detailing requirement is as per IS 456:2000 code of practice for plane & Reinforced Concrete and IS 13920:1993 Code of Practice for ductile detailing of reinforced concrete structure. Guideline on Monolithic Concrete Construction giving material requirements & design aspects prepared by BMTPC may be referred for design and other aspects of the system.

### Durability

Being constructed using concrete, durability of the structure can be achieved by using proper ingredient, grade of concrete & mix design as per IS 456:2000. Thickness of the wall is generally 100 mm with the reinforcement placed in the middle. Therefore, adequate cover is likely to be maintained.

### Thermal Behaviour of Structure

100 mm RCC Walls and Roof has thermal transmittance value as 3.59 W/m2K (IS 3792:1978). Since, it is more than the normal plastered brick wall (thermal transmittance 2.13 W/m2K), it is advised that implementing agency shall ensure proper planning for air ventilation provisions in housing units (IS 3792:1978).

### Acoustic

Average Sound reduction for 100 mm concrete is ≥ 45db (IS 1950:1962).

### Ease of fixing services

All electric and plumbing fixtures, lines has to be pre-planned and placed before concreting is done. Post construction alternation is not desirable.
## Scale of Economy

Scale of economy depends upon the volume of work and maximum number of repetition of the formwork achievable for the estimated time period of construction. Minimum 100 repetition of the formwork is desirable. For small project of less than 500 units, this system may not prove to be economical.

### Other features

1. Pre designed formwork acts as assembly line production and enables rapid construction of multiple units of repetitive type.
2. With proper planning, a slab cycle of 4 days can be achieved, which reduces the construction time considerably.
3. It is flexible in design and can form any architectural or structural configuration, such as stairs, windows, etc.
4. The formwork are manually handled. There is no need for heavy equipment & cranes etc.
5. Finish is such that it requires no separate plaster.

## Limitation

1. Initial investment for the formwork system is high compared to other forms & minimum of 500 houses in a year need to be built for economy.
2. Not much saving in construction in one storey structure.
3. A lead time of about 3 months is required for initiation of work, as the formwork are custom designed and manufactured as per the requirement of the structure.
4. Post construction alterations are difficult.
5. All the service lines are to be pre-planned in advance.
THE TECHNOLOGY

SELF COMPACTING CONCRETE

1. SCC will typically have a slightly higher compressive strength when compared to a conventional concrete of similar w/cm ratio.

2. Bond to reinforcement- While SCC bond strength is typically assumed to be higher than conventional concrete, this increase in bond is typically not considered in the design of the structure.

3. A slump flow value between 500 – 800 mm depending upon congestion of reinforcement.

4. The placement rate should be slowed to the point that there is sufficient time for the entrapped air to rise to the concrete surface.

5. When placing SCC with a concrete pump the hose of the pump should be placed inside the formwork and under the concrete surface whenever possible. This installation method both reduces the possibility of entrapping additional air within the SCC and eliminates the potential for material segregation due to free-fall around the reinforcing steel and form hardware.

6. Care should be taken to minimize vertical drops to 1.5 metres or less and to minimize horizontal flow to 10 metres or less.

7. Visual Stability Index (VSI) – The stability of self consolidating concrete can be assessed by visually evaluating the distribution of the coarse aggregate within the concrete mass after the spreading of the concrete has stopped.

8. T50cm Value – The T50cm value is recorded during the slump flow test by pre-marking a 50 cm diameter circle on the non-absorbent rigid surface and using a stopwatch to record the amount of time that is required for the concrete to reach this diameter.
THE TECHNOLOGY

**Code of Practice:**
List of generally applicable codes are as follows:

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<th>Sl No.</th>
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<td>Plain and reinforced concrete – codes of practice</td>
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<td>Code of practice for design loads (other than earthquake) for buildings and structures Part 1 Dead loads – Unit weights of building material and stored materials (Incorporating IS 1911 : 1967)</td>
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<td>Design Aids for Reinforced Concrete to IS 456 : 1978</td>
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<td>7</td>
<td>SP 34</td>
<td>Handbook on Concrete Reinforcement and Detailing</td>
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<td>8</td>
<td>IS 13920</td>
<td>Ductile Detailing of Reinforced concrete structures subjected to Seismic forces</td>
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**Grade of concrete**: M25 & M30

**Grade of reinforcement steel**: FE-500 & FE-500D

**Density of concrete**: 2500 kg/m$^3$

**Poisons ratio**: 0.2

**Young's modulus**: 27386 N/mm$^2$
ADVANTAGES OF MONOLITHIC CONSTRUCTION
Quality

• Use of homogeneous material – M 25 Self Compacting Concrete (SCC – free flow)

• Thus replacing bricks, mortar & concrete, which are used separately.

• Variations in operations/ skills are avoided
**Consistency**

- Standardised, system-driven repetitions are used in construction.
- Since single homogenous material is used, better consistency can be achieved in production & placement.
Superior Structural System

• Better structural rigidity & ductility due to shear wall design & use of homogeneous RCC.

• Moisture resistance is better due to monolithic (joint-free) construction.

• Better resistance to differential thermal stresses due to climatic changes (as compared to conventional construction)

• Better resistance to lateral forces – due to Earthquake/ tornado/ flood/ wind forces etc.
THE TECHNOLOGY

RMD TECHNOLOGY – ADVANTAGES?

Toothed joints in masonry courses or L-shaped dowel bars

Direction of earthquake shaking

(b) Wall B properly connected to Wall A (Note: roof is not shown): Walls A (loaded in strong direction) support Walls B (loaded in weak direction)

Figure 2: Advantage sharing between walls –

Figure 1: Reinforced concrete shear walls in buildings – an excellent structural system for earthquake resistance.

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Durability

• Durability & superiority of RCC over all other materials is proven.

• Monolithic structure eliminates joints, which cause cracks, moisture penetration and weakening of structure in the long term.
Sustainability

• Optimisation of construction materials

• Avoidance of wastages at site

• Utilisation of industrial bye-products like fly ash, slag

• Recyclability of materials after useful life of the structure (RCA – Recycled Concrete Aggregate)
Economy of Scale

• Due to the use of homogenous material, cost of divergent materials (as compared with normal construction) is reduced.

• More number of repetitions bring down the cost of formwork for mass construction.

• Relatively less number of labour hours, by increasing labour productivity

• Due to faster pace of Construction, reduction in Working Capital Cost
THE TECHNOLOGY

RMD TECHNOLOGY – ADVANTAGES?

Use of Existing Labour

• No advance skills / tradesmen are required for this technology.

• Existing labour force can be trained easily within few days of working at site.
THE TECHNOLOGY

1. Planning, Design & Reinforcement detailing
2. Selection of Shuttering
3. Selection of Concrete mixes
4. Skills to handle shuttering, reinforcement and concreting operations.
5. Optimising the cycle time.

IMPORTANT STEPS in IS R.M.D.?
EXAMPLE
WITH R.M.D. TECHNOLOGY
For understanding the process of shuttering calculations and construction time optimised,

Assuming construction of 9 building blocks, each 10 floor with 8 units on one floor.
1. Roof Slab

1. Calculation of shuttering Area to be used for the construction
1. Calculation of shuttering Area to be used for the construction

2. Shear Wall
1. Calculation of shuttering Area to be used for the construction

3. Corridor
4. Staircase

TOTAL AREA OF ONE TYPICAL
HALF SHUTTERING = A = 1+2+3+4

1. Calculation of shuttering Area to be used for the construction
Let's say, for casting a cluster of 10 floors by using 1/2 clustering shuttering (by maximum repetition for economic construction)

1/2 cluster = 1 Shuttering

Casting with Half Cluster Aluminum Shuttering

2. Calculation of time for construction of 1 cluster
2. Calculation of time for construction of 1 cluster

1 cluster casting with Half-Shuttering
1 Floor Casting

6 days + 6 days = 12 days
2. Calculation of time for construction of 1 cluster

1 cluster casting with Half-Shuttering
3 Floor Casting

42 days
1 cluster casting with Half-Shuttering
4 Floor Casting

Time
12 days + 12 days + 12 days + 12 days = 48 days

2. Calculation of time for construction of 1 cluster
2. Calculation of time for construction of 1 cluster

1 cluster casting with Half-Shuttering
10 Floor Casting

= 120 days (4 Months)
FOR 9 CLUSTERS = 3 HALF
ALUMINIUM  @ rate 'R'

TOTAL AREA = 'A*3'
TOTAL COST FOR 3 HALF SHUTTERING = (A*3) * R
= Rs. Y

3. Calculation of Cost for construction of 9 cluster
1 BLOCK is casted with 1/2 shuttering in 120 days
For 9 clusters:
4. Calculation of time for construction of 9 cluster

- Excavation
- Foundation
- Stilt Floor

= 5 Months
- 3 Clusters casted at same time
- 3 Half-Shuttering
- Foundation for next 3 clusters

4 Months

= 5 Months + 4 months

4. Calculation of time for construction of 9 clusters
4. Calculation of time for construction of 9 cluster

- Next three clusters
  = 6 Clusters casted
- Foundation for next 3 clusters

= 5 Months
  + 4 months
  + 4 months
4. Calculation of time for construction of 9 cluster

= 5 Months
  + 4 months
  + 4 months
  + 4 months

= 9 Clusters casted
4. Calculation of time for construction of 9 cluster

- Finishing

= 5 Months + 4 months + 4 months + 4 months + 6 months
4. Calculation of time for construction of 9 cluster

= 5 Months
  + 4 months
  + 4 months
  + 4 months
  + 6 months
  + 1 months
  = 24 months

- Testing and Commissioning
### 4. Calculation of time for construction of 9 cluster

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<td>NOV</td>
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<td>DEC</td>
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</table>

= 9 CLUSTERS

= 360 DAYS (12 MONTHS)
R.M.D.C.

vs

CONVENTIONAL CONSTRUCTION
- Walls, Columns, Beams and Ceiling functions as an individual component
- Less structural strength compared to RMDC.
- Less Disaster-resistant structure.

**CONVENTIONAL**

**VS**

**R.M.D.C.**

- MONOLITHIC STRUCTURE.
- Walls, 10-20 cm. thick, are joined to the foundation and the ceiling slabs.
- The high levels of dimensional accuracy.
- Disaster-Resistant structure.
**PLANNING**

**CONVENTIONAL**

- Offsets from Columns and Beams
- Less flexibility due to structural layout.

**R.M.D.C.**

- No columns and beams
- Clean corners without any offsets.
- Strict compliance with the architectural plan
- Greater architectural flexibility

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• Plastered walls lead to problems like 
plaster cracks.

• Non Uniform finish

• More of joints.

• Less Weather resistant

---

• Plaster work not required.

• Durable walls

• Minimum decoration, repair and refurbishment costs.

• Uniform finishes.
- Improper conduiting for services leads to leakage and seepage
- Dampness
- Less fire-resistant as compared to shear wall.

- The window and door frames, electrical conduits and sockets, water pipes and sewer ducts are pre engineered
- Eliminating the need for chiseling, drilling, boring and excavation work.
- Use of Pre engineered drawings
THUS, WE HAVE AN EFFICIENT BUILDING IN TERMS OF CONSTRUCTION.
NOW, HOW TO MAKE THE BUILDING EFFICIENT/SUSTAINABLE IN TERMS OF SERVICES?
Construction stage
- Domestic
- Construction activities

Operational stage
- Residential Domestic activities
- Landscape irrigation
- Visitors
- Service Staff
- Fire Fighting

Construction stage
- Laborer's domestic use
- Construction equipment
- D.G. SETS

Operational stage
- Residential
- Common Services
- Common Activity Zones
## Requirements

### Water footprint

<table>
<thead>
<tr>
<th>Requirement after Smart use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>840 kl/day</strong></td>
</tr>
</tbody>
</table>

### Requirement after Smart use

The priority is to improve efficiency of water use at the time of construction by:

- Eliminate water wastage on site
- Improve efficiency of water using dust suppression methods.
- Use of tertiary treated STP water for washing of equipment's and tools.

### Supply

- **JAL board**
- **Rainwater harvesting**
  
  **1350 kl/day**
  (taking in account the existing requirement on site)

### Generation

- **Recycled water**
  
  **773 kl/day**

### Generation Method

- **Passive Rainwater harvesting**

---

**CONSTRUCTION STAGE**

- Required for:
  - Temporary accommodation
  - General site activities including tool washing
  - Wet trades (brickwork, screeding, concreting and plastering)
  - Groundworks, including grouting and drilling
  - Dust suppression
  - Cleaning of tools and plant equipment, lorry washing
  - Commissioning and testing of building plant and services

- **STP of 2765 KLD** is set up before the construction work begins.
**Requirements**

**Water footprint**

3148 kl/day

- Drinking
- Food preparation and cleaning
- Personal hygiene
- Laundry
- Landscape Purposes
- Fire Fighting

**Requirement after Smart use**

30-40%

2046 kl/day

Low flow shower heads- 25%
Monoblock mixers-30%
Low flush toilets-50%
Pre paid water metering for each household- 30%
Automation- 50%
Dry toilets for common areas like club house, community center etc-80%
Aerators & flow restrictors-40%
Native plants for landscape-30%

**Supply Existing**

JAL board

675 Kl/morning

675 Kl/evening
(taking in account the existing requirement on site)

**Generation**

Rainwater harvesting

686 kl/day

Recycled water

2304 kl/day

**Generation Method**

Passive Rainwater harvesting

STP of 2765 kl/day is set up before the construction work begins as per the population usage on site
CONSERVATION OF WATER - WATER CYCLE (EXAMPLE)

1. Water resources

Municipal supply

- Water In: 3149 KLD
  - Fire Fighting: 384 KLD
  - Used: 2764 KLD
    - Drinking: 1798 KLD
    - Flushing: 966 KLD

Treated

- Drinking: 1438 KLD
- Flushing: 866 KLD

2. Conserve

- Rain water harvesting
- Efficient fixtures
- Water metering

3. Segregate

Reduces water consumption by 30%

Rainwater harvested
Used for domestic activities. If treated further, can be used for drinking as well.

4. Treatments

- STP
- Reused: 1069 KLD
  - Flushing
  - Horticulture

- Supplied: 1470 KLD

5. Used

- STP
- Black water treated and used for flushing and irrigation

6. Supplied

Excess water supplied from site to other areas by retro fittings to the existing water supply system

- Flushed: 2765 KLD
- Used: 966 KLD
- Grey water

Fire Fighting: 384 KLD

USED

- Flushing: 966 KLD
- Drinking: 1798 KLD

TREATED

- Flushing: 866 KLD
- Drinking: 1438 KLD

Water In

- Municipal supply
- Rain water
CONSERVATION OF ENERGY - ENERGY CYCLE (EXAMPLE)

1. Energy Resources
   - Sunlight
   - Electricity board

2. Conserve
   - Usage
     - 56765 KW
     - 217 KW
     - 250 KW
     - 33 KW
   - Common Area Load
     - Solar Energy
     - Supplied to Grid
   - Sub metering
   - Passive architecture
   - Efficient light fixtures

3. Generate
   - Solar panels over roof top
   - Solar panels over surface parking
   - Solar panels over covered landscaped areas

4. Not stored

5. Reduced usage by 30%

6. Supplied to grid

Single Line Diagram for Net Metering
WASTE MANAGEMENT SYSTEM

**Construction stage**
- Food wastes
- Leaves and grass clippings
- Most Paper waste

**Operational stage**
- Food wastes
- Leaves and grass clippings
- Most Paper waste

**Solid Waste**

**BIO DEGRADABLE**
- Plastic
- Glass
- Electronic
- Metal

**Non Biodegradable**
- Plastic
- Glass
- Electronic
- Metal

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WASTE MANAGEMENT SYSTEM

1. Source
- Treatment plants
- Community

2. Waste Reduction
- Bio-Degradable: 23255 kg/day
- Non-biodegradable: 11627 kg/day
- Disposed: 388 kg/day

Waste Generated: 38758 kg/day

3. Waste Sorting
- Bio-Degradable waste (60% of total waste generated)
- Non-Biodegradable waste (30% of total waste generated)
- E-waste recycling
- Paper recycling
- Plastic recycling
- Metal and Glass recycling
- E-waste recycling

4. Inert Waste
- (10% of total waste generated)
- Final disposal through government approved agency

Waste segregated and handed over to the different agencies as per their expertise.

Products which can be recycled inside the premises such as kitchen garbage shall used producing waste as generating manure.

WASTE GENERATED
- Bio-Degradable (60%)
- Non-Biodegradable (30%)
- Inert (10%)

WASTE DISPOSED
- Bio-Degradable: 23255 kg/day
- Non-biodegradable: 11627 kg/day
- Inert: 388 kg/day
Recycling of aggregate material from construction and demolition waste

**REUSE**
To make use of again without any processing i.e. to use in its original state.

**RECYCLING**
diverts waste materials from disposal to produce products with potential economic or ecological benefits.

**RECOVERY**
is a wider term that includes the re-use of waste products as a fuel source.

- Roads made using plastic
- Broken stones used in pathway paving
- Construction waste used in landscaping
- Construction waste used in filling
HOUSING PROJECTS

In Rapid Monolithic Construction Technology
RESIDENTIAL COMPLEX FOR POLICE PERSONNEL AT 15 bn INDORE

Client: Madhya Pradesh Police Housing Ltd
Location: 15 Bn, Indore (Madhya Pradesh)
Dwelling Unit: 1652 units
Type of building: Residential/Group housing
Built-up area: 160244 SQM
RESIDENTIAL COMPLEX FOR POLICE PERSONNEL AT 1st Bn INDORE

Client: Madhya Pradesh Police Housing Ltd
Location: 1st Bn, Indore (Madhya Pradesh)
Dwelling Unit: 2242 units
Type of building: Residential/Group housing
Built-up area: 106986 SQM
RESIDENTIAL COMPLEX FOR POLICE PERSONNEL AT PIPIYANA  INDORE

Client: Madhya Pradesh Police Housing Ltd
Location: Piplihana, Indore (Madhya Pradesh)
Dwelling Unit: 944 units
Type of building: Residential/Group housing
Built-up area: 80551 SQM

COMPETITION WON

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CRPF RESIDENTIAL QUARTERS & BARRACKS, GURGAON, HARYANA

Client: CPWD
Location: Kadarpur, Gurgaon
Dwelling Unit: 973 units
Type of building: Residential/Group housing
Built-up area: 105723 SQM

COMPETITION WON
<table>
<thead>
<tr>
<th>Client</th>
<th>CPWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Kadarpur, Gurgaon</td>
</tr>
<tr>
<td>Dwelling Unit</td>
<td>973 units</td>
</tr>
<tr>
<td>Type of building</td>
<td>Residential/Group housing</td>
</tr>
<tr>
<td>Built-up area</td>
<td>105723 SQM</td>
</tr>
</tbody>
</table>

CRPF RESIDENTIAL QUARTERS & BARRACKS, DWARKA, DELHI

COMPETITION WON

© ARINEM Consultancy Services Pvt Ltd
Client: Lucknow Development Authority
Location: Sec-4, Gomti Nagar Extension, Lucknow
Type of Building: Residential/Group housing
Dwelling Units: 2933
Estimated Cost: 780Cr.
Built-up area: 475000 SQ.M.
PARIJAT APARTMENTS, LUCKNOW

Client: Lucknow Development Authority
Location: Lucknow
Type of buildings: Residential/Group housing
Dwelling Units: 406
Estimated Cost: 150 Cr.
Built-up area: 66397.66 SQ.M.
# DHENUMATI APARTMENTS, LUCKNOW

<table>
<thead>
<tr>
<th><strong>Client:</strong></th>
<th>Lucknow Development Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location:</strong></td>
<td>Dalibagh, Lucknow</td>
</tr>
<tr>
<td><strong>Type of building:</strong></td>
<td>Residential/Group housing</td>
</tr>
<tr>
<td><strong>Dwelling Units:</strong></td>
<td>56</td>
</tr>
<tr>
<td><strong>Estimated Cost:</strong></td>
<td>25.35 Crores</td>
</tr>
<tr>
<td><strong>Built-up area:</strong></td>
<td>9618.39 SQ.M.</td>
</tr>
</tbody>
</table>
SARGAM APARTMENTS, LUCKNOW

Client: Lucknow Development Authority
Location: Sector – J (ext.) Jankipuram, Lucknow
Type of building: Residential/Group housing
Dwelling Units: 720
Estimated Cost: 186.99 Cr.
Built-up area: 93700.01 SQ.M.
<table>
<thead>
<tr>
<th><strong>LOW COST HOUSING FOR URBAN POOR / SLUM REHABILITATION, DELHI</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client:</strong></td>
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<tr>
<td><strong>Location:</strong></td>
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<td><strong>Type of building:</strong></td>
</tr>
<tr>
<td><strong>Dwelling Unit:</strong></td>
</tr>
<tr>
<td><strong>Estimated Cost:</strong></td>
</tr>
<tr>
<td><strong>Site area:</strong></td>
</tr>
<tr>
<td><strong>Built-up area:</strong></td>
</tr>
</tbody>
</table>
GROUP HOUSING AT ALLHABAD

Client: Allahabad Development Authority
Location: Allahabad
Type of building: Residential/Group housing
Dwelling Units: 2941
Estimated Cost: 468.53 Cr.
Built-up area: 53749.05 SQ.M.
<table>
<thead>
<tr>
<th>Client:</th>
<th>U.P. Housing Development Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>Vrindavan Yojna, Sec-16, Raibareilly Road, Lucknow</td>
</tr>
<tr>
<td>Type of Building:</td>
<td>Residential/Group housing</td>
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<tr>
<td>Dwelling Units:</td>
<td>1056</td>
</tr>
<tr>
<td>Estimated Cost:</td>
<td>387.2 Cr.</td>
</tr>
<tr>
<td>Built-up area:</td>
<td>123050.53 SQ.M.</td>
</tr>
</tbody>
</table>

**HIMALAYA ENCLAVE, LUCKNOW**
Client: U.P. Awas Evam Vikas Parishad
Location: Ghaziabad
Type of Building: Residential/Group Housing
Dwelling Units: 1292
Estimated Cost: 259.51 Crores
Built-up area: 206261.33 SQ.M.

AWARD winning project
Client: Lucknow Development Authority
Location: Sec-4, Gomti Nagar Extension, Lucknow
Type of Building: Residential/Group housing
Dwelling Units: 240
Estimated Cost: 56.57 Cr.

VANASTHALI APARTMENTS, LUCKNOW
Client: U.P. Housing Development Board
Location: Vrindavan Yojna, Raibareilly Road, Lucknow
Type of Building: Residential/Group housing
Dwelling Units: 432
Estimated Cost: 180 Cr.
Built-up area: 85577.26 SQ.M.
Client: U.P. Housing Development Board
Location: Vrindavan Yojna, Raibareilly Road, Lucknow
Type of Building: Residential/Group housing
Dwelling Units: 616
Estimated Cost: 252.03 Cr.
Built-up area: 65304.04 SQ.M.

AKASH APARTMENT, LUCKNOW
PANCHSHEEL MULTISTORIED HOUSING (1&2), LUCKNOW

Client: Lucknow Development Authority
Location: Vikalp-Khand-3 Gomti Nagar, Lucknow
Type of Building: Residential/Group housing
Dwelling Units: 584
Estimated Cost: 52.86 Cr.
Built-up area: 35993.60 SQ.M.
Client: U.P. Awas Evam Vikas Parishad
Location: Sec - 5 Saharanpur Road Yojna, Ghaziabad
Type of Building: Residential/Group housing
Dwelling Units: 1168
Estimated Cost: 257.82 Cr.
Built-up area: 89838.72 SQ.M.

SAPNA ENCLAVE, GHAZIABAD
Client: Lucknow Development Authority
Location: Various Locations, Lucknow
Type of Building: Residential/Group housing
Dwelling Units: 9232
Estimated Cost: 500 Crores
Built-up area: 91248 SQ.M.

SULABH & SAHAJ AWAS YOJNA
Client: Overseas Infrastructure Alliance (India)

Location: Male & Thinadhoo

Type of building: Residential/Group housing

Dwelling Units: 485

Estimated Cost: 40 Million US$

Built-up area: 52190.77 SQ.M.
### PANCHSHEEL HOUSING (LIG & EWS), LUCKNOW

<table>
<thead>
<tr>
<th>Client</th>
<th>Lucknow Development Authority, Lucknow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Various locations in Lucknow</td>
</tr>
<tr>
<td>Type of Building</td>
<td>Residential/Group housing</td>
</tr>
<tr>
<td>Dwelling Units</td>
<td>1184</td>
</tr>
<tr>
<td>Estimated Cost</td>
<td>58 Cr.</td>
</tr>
<tr>
<td>Built-up area</td>
<td>35993.6 SQ.M.</td>
</tr>
</tbody>
</table>

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THANK YOU

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