Comparative Study of Reinforced Cement Concrete and Prestressed Concrete

Asif Nazir[1], Usama Khan[1], Hafiz Muhammad Shahzad Aslam[1], Rana Muhammad Umar Farooq[2]

[1]*Department of Technology (Division Civil Engineering Technology), The University of Lahore, Pakistan*
[2]*Department of Civil Engineering, University of South Asia, Lahore, Pakistan*

***Abstract*: The purposed research work is an effort to determine why the PSC is better than RCC, but instead of being better we still use RCC at some places due to economic reasons and limited resources. Nowadays Reinforced Concrete structures and Pre-stressed Concrete Structures are mostly used. The reinforced concrete structure have many advantages as compare to steel structures so most of the high rise buildings are constructed by using reinforced concrete frame structures. Similarly most of the overhead bridges construction use pre-stressed concrete .It is very important to have a well knowledge about both RCS and PSC before the construction of structures for to avoid the failure of structure in the future. The cracking and deflection are common problem faced in design of reinforced concrete and pre-stressed concrete structure. Due to that reason the before the start of construction work proper structure design needs to be completed. So in this research work we are going to discuss the detailed study on Reinforce Concrete and pre-stressed Concrete, there advantages, disadvantages, properties and in the end there comparison with each other.**

***Keywords*: PSC: Pre-stressed Concrete, RCC: Reinforced Cement Concrete, HRB: High Rise Building**

I. INTRODUCTION

A. General

The concrete is stone like man made construction material widely used for the construction of projects. It is prepared by mix proportioned of ordinary Portland cement, aggregates (fine aggregated as sand, and coarse aggregates as crushed stone) and water. In compression concrete have a very good strength but Concrete have but in tension concrete have less strength as compare to compression. The percentage of tensile strength of concrete is ranges from 5 to 10 percent of its compressive strength. When the external forces are applied on the concrete surface the flexural cracks developed due to less tensile capacity of concrete. For to safe the structure from these cracks all the external concentric or eccentric loads are applied on the lateral direction of the structural element due to this reason the tensile stresses are eliminated. After this the concrete sections are normally behave elastically, and in compression the full capacity of the concrete structures can be effectively utilized in overall depth of the concrete sections when all the external loads act on the structure component.

II. MATERIALS & METHODS

REINFORCE CEMENT CONCRETE (R.C.C)

A. General

The Concrete is a stone like man made construction material that is prepared by mix proportioned of binding material as cement, aggregates (Fine and Coarse aggregates) and water to harden for the construction of desired structure in required shape and dimension. The maximum volume of concrete is covered by fine and coarse aggregates. Cement and water are react chemically to bind the aggregate particles into a solid mass.

B. Reinforce Concrete Materials

i OPC (Ordinary Portland cement)

There is a large variety of cement available in the market. Portland cement consist of the following constituents

Table. 1: Grade of Steel

Description	Minimum	Maximum
➢ Lima Cao	60%	70%
➢ Silica sio_2	17%	25%
➢ Alumina Al_2o_3	3%	8%
➢ Iron Oxide Fe_2o_3	0.5%	6%
➢ Magnesia Mgo	0.1%	4%
➢ Soda and Potash	0.2%	1%
➢ Sulphur Trioxide	1%	3%
➢ Free Lime	0%	1%

ii Coarse Aggregates

The coarse aggregates are inert materials that are used in concrete for to increase the volume and strength of concrete, e.g.: gravel, stone (crushed stone) etc. The nominal size of the coarse aggregate for reinforced concrete work is 20mm which is generally considered satisfactory.

iii Fine Aggregates

As fine aggregate the sand is used in concrete. The size of the sand particles is less than 4.75 mm

iv Water

Water fit for drinking is good for concrete.

v Reinforcing Materials

Concrete is weak in tension, due to this reason reinforcement is provided in concrete for to bear the tensile stresses in RCC structures, Reinforcement can be mild steel bars, ribbed steel, steel fibers, glass fibers or bamboo reinforcement.

vi Grade of Steel

Table.2: Grade of Steel

Grade	MPa	Psi	Ksi
40	280	40,000	40 ksi
60	420	60,000	60 si

C**.** *Properties of Concrete*

i Weight

The reinforced concrete which is made by binding material, fine aggregates, coarse aggregates and water for this normally the unit weight used as 24000 N/mm^2 (2400kg/m^3.

ii Compressive Strength:

The compressive strength of concrete is very high. The compressive strength of concrete depends primarily on age (days), amount of cement (cement content) and the W/C (water cement ratio). Properties of strength strengths are based on the 28 days strength of concrete. The concrete strength at 7 days is about two-thirds of concrete strength at 28 days with the use of OPC (Ordinary Portland cement).

Table 1.3 shows the grades and the Compressive strength of Concrete

S.No	**Exposure**	**Plain Concrete**			**Reinforced Concrete**		
		Minimum Cement Content kg/m^3	Maximum Free Water cement ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free Water cement ratio	Minimum Grade of Concrete
i.	Mild	220	0.60	M10	300	0.55	M20
ii.	Moderate	240	0.60	M15	300	0.50	M25
iii.	Severe	250	0.50	M20	320	0.45	M30
iv.	Very Severe	260	0.45	M20	340	0.45	M35
v.	Extreme	280	0.40	M25	360	0.40	M40

Increase in Strength of concrete with Age

Normally concrete gain its strength at 28 days. The increase in strength of concrete is depends on grade of concrete, amount and cement type, curing and temperature conditions etc. In design normally the 28 days strength of concrete is used. The structural design of concrete structures is always based on the strength of concrete at 28 days with the increase in age of life the strength of concrete may increase.
The increase rate in compressive strength of grade M30 and for other's concrete may be determined by practically.
However for guidance following increases in strength with age can be taken as given in table 1.4.

Table 1.4: Age Factor

After Months	Age Factor
3 Months	1.10
6 Months	1.15
1 Year	1.20

D. PRESTRESSED CONCRETE (P.S.C)

i. General

It is type of concrete which is produced by pre stressed process in which the pre-stressing force is applied on High strength steel (Steel 240,270 grade) by pulling then through hydraulic jack.

ii. Purpose of Pre-stressing Concrete:

The objective of pre stressing is to minimize the natural weakness of concrete and enhance the strength of concrete. And reduced or eliminate the tensile strength in pre-stressed.

iii. Principal/Role of Pre-stressing:

The tensile stresses in pre-stressing steel will balanced by compressive stress generated by the high tensile strength steel in a concrete member before loads are applied.

The stressing steel in concrete is used to produce the compressive stress that offsets the tensile stress in concrete.
High tensile Strength Steel used in pre-stressing Concrete:

a. Wires
b. Strands
c. Tendons
d. Cables

- *Wires*

Pre-stressing wires is a single unit that is made of steel.

- *Strands*

Strands are formed by the combination of two, three or seven wires.

- *Tendons*

Combination or group of strands is termed as tendons.

- *Cables*

Group of tendons form of a cable

E. Advantage

i. Durability will be more.
ii. Less cracking.
iii. Act like homogenous structure.

Pre stressed concrete member have long life and more durability due to less cracking

F. Comparison of Pre-tensioning and Post tensioning

i. Pre tensioning

- In steel the tension is provided first and then the concrete will poured after the concrete will become harden then the jack will released.
- It is suitable for short span and the pre cast product like electric poles.
- In pre tensioning cables are basically straight and horizontal (for tendons profile).
- The losses in pre tensioning are more as compare to post tensioning.

ii. Post Tensioning

- Concreting is done first then wires are tensioned and anchored at ends.
- Suitable for long span.
- The post tensioning cable may alliance in any shape. It is more economical for long span bridges.
- Losses in post tensioning are less as compare to pre tensioning.

G. Devices for Tensioning:

The different type of devices are used for tensioning in steel are grouped under. (Figure 1.3 shows the different method for tensioning)

- Mechanical devices
- Hydraulic devices
- Electronic devices
- Chemical devices

Fig.1.3: Tensioning Devices

Figure 1.3 shows the different method for tensioning

2.7 The table shows the difference Between Pre-cast concrete and cast in place concrete

Description	Precast Concrete	Cast in place
1. Machine and Labor	Required more machinery	Required less Machinery
2. Cost/Expenses	The initial cost for large project is less because the cost of frame work cost is less.	The initial cost is high. Cast in place structures requires less maintenance.
3. Time Frame	Less construction time for precast concrete is required. Structure can be created in advance.	More construction time required due to frame work installation.
4. Concrete Quality	Better quality of concrete achieved due to concrete plant used.	Quality of concrete is low due to the numbers of factors effect on quality of concrete.
5. Weather Condition	Precast concrete structures are prepared in a controlled environment. The environment is not effect on construction work.	The Cast in place concrete work effect by the weather condition. This may cause in delay the construction work.
6. Repair & Maintenance	The precast concrete structure required more maintenance cost.	The cast in place structure required more maintenance cost.
7. Recycle	Used for same requirement for another location after remove.	Difficult to use for another location.
8. Durability	Precast structures have less durability due to many joints in structures.	Cast in place structures have more durability due to less joints and monolithic construction.
9. Sustainability	In precast structure less material used so sustainability is greater as compare to cast in place structures.	Cast in place concrete structures used more material so they have less sustainability as compare to precast structures.

III. CONCLUSIONS

A. Reinforced Cement Concrete

i In reinforced cement concrete the basic materials are concrete and steel.
ii The above portion of neutral axis (N.A) is considered for resisting for external forces.
iii Due to high tensile stress steel as reinforcement this results in more cracks in tensile zone of concrete.
iv Reinforced concrete have less crack resistance ability which may causes corrosion of both reinforcement and concrete.
v Reinforced concrete structures are not economical for longer span.
vi Reinforced concrete structures have less stiff as compare to PSC.
vii Weight of structure is not reduced
viii Quantity of steel required is more
ix In reinforced concrete structures the steel used with the yield limit 200-300 N/mm2
x M-20 (Minimum grade)

B. Pre-stress Cement Concrete

i In pre-stressed cement concrete high strength steel and high strength concrete are used.
ii Complete part of the structural member will contribute against external forces due to pre-stressing in concrete.
iii Under the applied load or external forces there is no chances of cracking because high tensile steel is used.
iv Pre-stress concrete have more crack resistance which prevents the both concrete and steel from corrosion, rusting and deterioration.
v Pre-stress concrete structures are more economical for longer span.
vi Pre-stress concrete structures are more stiffness as compare to RCS.
vii Due to the use of high grade concrete and high grade steel the dead load of the member is reduced.
viii In pre-stress concrete members the requirement of steel is 1/3rd as compare to R.C.C.
ix Pre-stress concrete member have more strength.

- *x* Grade M-40 concrete is used for Pre-tensioning, and grade M-30 concrete is used for Post-tensioning

IV. RECOMMENDATIONS

- PSC is better than RCC in every way so if you have sufficient funds then always select PSC.
- According to the obtain data RCC is cheaper for up to 11.25 meter beam Span but if the span is more than 11.25 meter than we recommend PSC.
- For Mega Structure like Orange Line Train in Pakistan use PSC because of Economical and High Strength.
- If Fire chances are high use PSC with those aggregates of high fire resistance.
- Always use Standard Codes while designing any structural element.
- We recommend doing a practical comparison on this theoretical research by designing RCC and PSC beams and analyze their behavior.

REFERENCES

[1] Concrete Material by Sandor Popovics (2nd Edition)
[2] Concrete Material by A. M. Nevil(4th Edition)
[3] Design of Reinforced Concrete by Jack C. McCormac (3rd Edition)
[4] Prestressed Concrete by N. Rajagoplan(2nd Edition)
[5] Design of Prestressed Concrete Structures by H. Nilson(14th Edition)
[6] Concrete Technology by M.S Shetty (1st Edition)
[7] Prestressed Concrete by N Rajagopalan(2nd Edition)
[8] Concrete by P. Kumar Mehra and Paulo J.M Monteiro(1st Edition)
[9] Reinforced Concrete (Mechanics and Design) by James K. Wight and G. Macgregor(6th Edition)
[10] ACI Cornmittee 350, 1989. Environmental Engineering Concrete Structures (AC1 350R-89).AmeriConcrete Institute, Detroit
[11] ACI Cornrninee 344. 1989. Design and Construction of Circular Prestressed Concrete Structures (344). American Concrete Institute, Detroit.
[12] R. Panchal, Dr. S.C. Patodi, “Steel-concrete composite building under seismic forces”, Vadodara, India.
[13] IS 456: 2000, “Code for practice of plain and reinforced concrete code of practice”
[14] R. Panchal, P.M. Marathe (2011), “Comparative Study of RCC, steel and composite (G+30 storey) building”, Nirma University, Ahmedabad, India
[15] IS 11384:1985, “Code of Practice for Design of Composite Stru