ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 5, Issue, 04, pp. 4050-4054, April, 2015

International Journal of
DEVELOPMENT RESEARCH

Full Length Research Article

ASSESSMENT OF PRESTRESSED CONCRETE APPLICATIONS IN NIGERIA CONSTRUCTION SECTOR TOWARD INFRASTRUCTURAL STABILITY AND NATIONAL DEVELOPMENT

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ARTICLE INFO

Article History:
Received 11th January, 2015
Received in revised form
14th February, 2015
Accepted 19th March, 2015
Published online 29th April, 2015

Key words:
Prestressed Concrete,
Assessment,
Applications,
Infrastructural Development.

ABSTRACT

The ever increasing failures and collapse of buildings. Bridges, etc in Nigeria is not only a set back to the construction industry, lives and properties, but also another name as "underdeveloped'' with many labeled descriptions in terms of infrastructural facilities. These facilities are the ones on that are expected to ensure stability towards Economic development of the country, if the expected stresses have been induced in them during the construction periods. This is the primary aim of prestressed concrete. This paper therefore assessed prestressed concrete applications in Nigeria construction sector towards infrastructural development.

INTRODUCTION

According to ACI (American concrete Institute) prestressed concrete is a material that has internal stresses induced to balance out to a desired degree and stresses due to externally applied loads. Since tensile stresses are undesirable in concrete members, the object of prestressing is to create compressive stresses (prestress) at the same location as the tensile stresses within the members so that the tensile stresses will be diminished or will disappear all together. The diminishing or elimination of tensile stresses within the concrete usually results in members to have sewer cracks or crack free at service load levels. This is one of the advantages of prestressed concrete, particularly in corrosive atmosphere. Prestressed concrete offers other advantages because the Beams cross – sections are primarily in compressions and diagonal tension stresses are stiffer at service loads. In addition, sections of the Beams can be smaller, which can result in less dead weight.

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An over view on prestressed concrete

- The development of early cracks in reinforced concrete due to in compatibility in the strains of steel and concrete was the major starting point in the development of a new material called "prestressed concrete". The application of permanent compressive stress to a concrete, which is strong in compression and weak in tensile strength of the material, because the subsequent application of tensile stress must first notify the compressive prestress.

- The present state of development in the field of prestressed concrete is due to the continuous research carried out by Engineers and scientists in the field during the last few decades. The idea of prestressing to counteract the stresses due to loads was first put forward by the Austrian engineers in 1986. A further development on the loses of prestress due to elastic shortening of concrete was carried out. The importance of losses in prestressing due to shrinkage of concrete was also recogmsed. The use of unbounded tendons was also demonstrated in the construction of a major bridge of the deep – girder type, in which prestressing wires were placed inside the girder without any bond. Losses of prestress were compensated

by the subsequent retention of the wires. Based on the exhaustive studies of properties of concrete and steel, some engineers approved the advantages of using high – strength steels and various losses of prestress due to creep and shrinkage of concrete. The use of prestressed concrete later, spread outwards and many long – span Bridges were constructed between 1945 and 1950 in Europe and the United States. During the last many civil Engineering structures.

MATERIALS AND METHODS

The increasing rate of technological advancement and research in concrete technology is moving in a fast speed, thereby making the old method of design and construction of highly sophisticated structures to be obsolete. The era of prestressed concrete applications in Nigeria construction industry has yielded a tremendous result over the years. This assessment was carried out through the following means:-

- critical study of various prestressed concrete stmetures that has been built over the years in many parts of Nigeria, especially in big cities like Abuja, the federal capital territory (FCT), Lagos Ibadan Port – Harcourt, Kaduna , Calabar Akwa –Ibom, Makurdi, e.t.c
- personal site visits to places where prestressed concrete construction is carry out daily with standard construction equipment
- A detailed study of literature materials and texts books written and published by experts from different parts of the world.
    - The above methods proved that the low tensile strength of ordinary Reinforced concrete which has certain weaknesses such as cracking, deflections and strength can be improved or eliminated by prestressing the concrete

DISCUSSION

Prestressing of concrete is defined as the application of a predetermined force or moment to a structural member in such a manner that the combined internal stresses in the member resulting from this force or moment and from any anticipated condition of external loading will be confined within the specific limit. Prestressing wires placed eccentrically in simple concrete beam produce an axial compression and hogging moment. Under service loads, the same is expected to develop sagging moments. Therefore, it is possible to have the entire section in compression when the service loads are imposed.

Prestressed concrete structures are used for long span bridges longer and overhanging beams of high rise buildings and other allied structure which not only resists the wind loads, but also takes care of serviceability limit states. The high strength concrete and the high tensile steel used usually results in enhancing the modulus of elasticity marginally. The decompression moment that develops in prestressed concrete structures is in no way comparable to reinforced concrete structures. Its cross sectional dimensions are smaller and thus reduces the cost of foundations which is economical. It is an established fact that prestressed concrete structures are structurally sound and physically superior to reinforced concrete structures. Generally, prestressing of concrete means the artificial creation of stresses in a structure before loading, so that the stresses which then exist under the load are more favorable than otherwise be the case.

Classifications of prestressed concrete structures

Class I structures: - tensile stresses are not permitted in these structures, hence any cracking under service loads. This type is known as fully prestressed concrete structures

Class II Structures: - Limited Tensile stresses are permitted, but there should be no visible cracking under service loads. Tensile stresses should be less than 3MPa

Class III Structures: - Tensile stress, cracking under service load is permitted. The width of surface cracks should be between 0.1mm to 0.2mm. Such members are referred to as partially prestressed members

Reinforced concrete versus prestressed concrete

- In a Reinforced concrete structure, steel is an integral part and it resists the force of Tension which concrete cannot resist. The tension force develops. In steel when concrete begins to crack are transferred to steel through bond. The stress in steel varies with the bending moment. The stress in steel should be limited in order to control the cracking in reinforced concrete.
- In a prestressed concrete structure, high tensile steel is primarily a means of inducing a force of prestress that is applied at the ends of a beam. Due to the transfer of prestress to concrete, it is usually under heavy compression, and the beam normally end up hogs up and subjected to upward deflection. When it is subjected to service loads, it comes unto horizontal position and them deflects downwards. Therefore a prestressed concrete depends on the steel strains. Since the concrete is under heavy compression, no crack develops.

Advantages of Prestressed concrete over Reinforced concrete construction

1. It is free of cracks under service loads and enables the entire section to take part in resisting moments.
2. The use of high strength concrete and steel in prestressed concrete members usually results in lighter and slender member that could be possible by using reinforced concrete with mild steels as reinforcement.
3. In prestressed concrete, steel is no longer required for reinforcement, but it is provided there as a means of prestressing the concrete.
4. It eliminate corrosion of steels when the structure is exposed to weather
5. Cracking seldom occurs by chance. If a crack develops due to moving loads, it is gets closed as the load crosses over
6. prestressed concrete sections are much smaller than reinforced concrete sections because dead load moments are neutralized by the prestressing moments and shear forces are reduced

7. It is much economical to reinforced concrete sections
8. precast prestressed Elements saves the cost of centering with high quality control
9. Its high ability to resist impact, high fatigue resistance is considerable in design.
10. In prestressed members, dead loads may be counter-balanced by eccentric prestressing, whereas in Reinforced concrete dead loads are of great importance there is the saving of materials in prestressed presence
11. prestressed concrete members possess better resistance to shearing forces due to the effect of compressive stresses presence
12. prestressed concrete contributes to improved durability under aggressive environment conditions
13. long span structures are possible in prestressed concrete,
14. factory production such as railway sleepers electric poles are possible in prestressed concrete members, where as reinforced concrete members have to be cast in situ
15. Prestressed concrete members are usually tested before use but reinforced concrete members cannot be tested as such.
16. Prestressed concrete structures often deflect appreciably before ultimate failure by giving ample warning before collapse. There is no such indication under reinforced concrete
17. Fatigue strength of prestressed concrete members is better due to small stress variation in prestressing of steel. Therefore it is recommended for dynamically loaded structures
18. multiple units of production are possible by centralizing the pretressing work which reduces labour cost and also provide better control of products

Disadvantages of Prestressed Concrete Construction

1. It requires end anchorages and bearing plates
2. it requires complicated form work
3. it needs high quality prestressing systems to minimize losses
4. labour cost involved is usually greater than that of reinforce concrete
5. it requires better technical supervision and quality control
6. initial Equipment cost for prestressing is usually very high
7. the cost of high strength of materials is high
8. Availability of Engineers. Experienced with prestressing work is scanty
9. slender sections are often difficult to transport
10. prestressed concrete sections are less fire resistant
11. No opening can easily be made once the members prestressed.

Prestressing systems of concrete structures

The prestressing system of concrete structures is induced by either of the two processes thus:-

Pre- Tensioning :- thus is a method of prestressing concrete in which the tendons or cables are tensioned before the concrete is placed in its permanent position / in this method tendons are temporarily anchored and tensioned and the prestress is transferred to the concrete after it has hardened. This method is usually used for factory products like prestressed railway sleepers and electric poles

Post – Tensioning:- this is a method of prestressing concrete in which the tendons or cables are tensioned after the concrete has hardened. In this method tendons are placed in sheathing at suitable place in the suitable place in the members before casting and after hardening of concrete the tendons are tensioned and anchored by the use of anchorage devices

Concrete for prestressed construction

Ordinarily, concrete of substantially higher compressive strength is used for prestressed structures than for those constructed of ordinary reinforced concrete. Stronger concrete is generally required for prestressed than for reinforced concrete work. Higher strength is necessary in prestressed concrete in order to minimize the cost and to use commercial anchorages, to have resistance in tension shear, bond and bearing. High strength concrete is less liable to shrinkage and cracks.

Reinforcement for prestressed concrete

The steel used in prestressed concrete usually possess higher yield strength (i.e.1600 mpa). High strength steels are often obtained by alloying which permits the manufacture of such steels under normal operating conditions. The cost common method for increasing the tensile strength of steel for prestressing is by cold – drawing method.

Design Requirement for Prestressed Concrete Structures

Most of the advantages of prestressed concrete are at service load levels, and since permissible stresses in the concrete often control the amount of prestress force to be used, the major part of the analysis and design calculations are made easy by using service loads. The calculation computations includes:-

I. Areas and moments of Inertia of sections
II. Modulus of Elasticity of concrete
III. Modulus of Elasticity of steel
IV. Permissible stress for steel
V. Permissible stress for concrete
VI. Compressive stress due to initial prestress
VII. Compressive strength due for final prestrss
VIII. Flexural stresses

General Application of Prestressed Concrete

The use of prestressed concrete has spread to many areas of Civil Engineering construction works. Such areas of applications are:-

(I.) construction of long span bridges
(II.) industrial shell roofs
(III.) Marine structures
(IV.) Water – Retaining structures, such as dames,
(V.) Transmission poles
(VI.) Electrical poles
(VII.) Railways sleepers, etc

Most of the areas of application mentioned above are everywhere in every cities and towns of Nigeria today in large number, and providing valuable services for the growth of the country. These structures were built by construction companies with standard equipment and trained experts.

Assessment of prestressed concrete application in Nigeria construction sector towards infrastructural stability and development

The Assessment of prestressed concrete Application in Nigeria construction sector can be critically Look In To as Follows:-

THE NATIONAL DEVELOPMENT: - The government of Nigeria has always objectives to be pursuit. The development usually covers the major aspect of country, such as infrastructural development in terms of loads, electricity supply (gas Hydro – electricity, telecommunication, water supply, dams, etc)

The government plants are usually set out in stages i.e . 5 years plan, 10 years plan, etc. for implementation, but suffice to note that these plans are always thwarted.

- Most Nigeria agree that the major reason for our under development is poor political leadership, which has affected infrastructural development at federal state, aand even at local level. Other factors associated with poor political leadership are poor maintenance culture and lack of inadequate implementations will power and low level of technological advancement in construction sector within the country
- The applications of prestressed infrastructural development covers areas like supper Highways systems, ever – improving water transportation facilities, Harbors, airspace, airports, air traffic, etc. A breakdown of these infrastructural facilities within Nigeria can be stated below:-

(A) Air transportation

(i) Nnanmdi Azikwe International Airport, Abuja
(ii) Muritala Muhammed International Airport, Ikeja – lagos
(iii) Mallam Aminu Kano International Airport Kano
(iv) Port – Harcourt International Airport, port – Harcourt

Some of the newly built airports in some states of recent are as follows:-

1. Akwa – Ibon international Airport
2. Asaba international Airport at Asaba

The available domestic Airports in the country are:-

(i) Margaret Ekpo INTERNATIONAL Airport, caliber
(ii) Yola international Airport yola
(iii) Ibadan Airport
(iv) Akure Airport
(v) Benin Airport
(vi) Sokoto Airport
(vii) Maiduguri Airport
(viii) Katsina Airport
(ix) Kaduna Airport
(x) Jos Airport
(xi) Minna Airport
(xii) Imo Airport, owerri
(xiii) Enugu Airport
(xiv) Makurdi Airport
(xv) Bauchi Airport
(xvi) Ilorin Airport
(xvii) Wari Airport

B. water transportation (seaports) Nigeria presently has the following seaports:-

(i) Lagos:-

(a) Apapa port complex including the container terminal
(b) Tin can island including the Roko Terminal

(ii) Sapele port

(i) warri port
(ii) port –Harcourt port

(iii) Onne – port
(a) Federal ocean terminal
(b) Federal lighter terminal

(vi) Calabar port

A detail analysis of all the infrastructural facilities mentioned above shows that they were designed and constructed. In the past. The amazing question to ask is this: - Are all the facilities listed above still operating as expected of them, or have they failed and even collapsed? Are the recent built ones fully of prestressed concrete construction to the required standard? Certainly the answer to the questions above cannot be completely yes. The same experience applies to some Bridges and high rise buildings in major parts of the country. How many of them are still standing? Certainly very few of them. This is an indication that prestressed concrete construction needs a serious visitation and attention in Nigeria.

Recommendation

(i) Government should encourage the pursuit of excellence in every profession, especially in the professional practice of infrastructural facilities construction of prestressed in the professional facilities construction of prestressed concrete strictures that will lead towards stability and national development
(ii) Attention: should be paid to the supervision of projects in order to secure the investment already made in the area of infrastructure
(iii) Nigeria should make a determined effort to utilize its human and material resources, so as to be able to advanced the course of technological innovations and exploitation in all areas. This will enhance the development of specialized skills, which would allow the country to reap the abundant harvest, especially in the field of construction
(iv) Infrastructural design and management division should be established in every government department and parasitical in change of I infrastructural, to oversee the

design, construction and management, and compiling and keeping the data of built infrastructure for the country.

(v) Construction sector should be encourage and allow by the government at federal, state and local to perform their best. Services within reach, with the available standard construction equipment for construction of prestressed concrete structures.

(vi) The professionals in the construction sector should work hand in hand with other in the same field, in order to achieved professional services that would promote their performance.

(vii) Proactive research and development on methods of design and material utilization for prestressed concrete field should be encourage in universities, colleges of Technology and research institutes.

Conclusion

Growth is normal in life. The same applies to every profession that is contributing to the infrastructural development of the country. Nigeria has had decayed and failures of structural facilities in the past. Countries such as Malaysia, India, Yugoslavia, Korea, united Arab emirate, Dubai, etc had set back in the area of infrastructural development, but they are still developing. Nigeria can still achieved the world best design prestress concrete structures, if all hands (i.e. the government and individuals) will be on deck and to work together in order to achieved infrastructural stability towards national development

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Basic Teminology In Prestressed Concrete Design

- **Tendon: -** A stretched element that is usually used to impact prestress to the concrete. Generally, high tensile steel wires, bars cables or strands are usually used as tendons
- **An chorage: -** this is a device that is generally used to enable the tendon to impact and maintain prestress in concrete. The commonly used anchorages are clips, cones, wedges and anchor plates
- **Pre: –** tensioning is a method of prestressing concrete in which the tendons are tensioned before the concrete is placed. The prestress is introduced to the concrete by bond between concrete and steel.
- **Post – Tensioning: -** Is a method of prestressing concrete by tensioning the tendons against hardened concrete. The prestress is impacted to the concrete by bearing.
- **Bonded prestressed concrete:** - is a concrete in which prestress is usually introduced to concrete through a bond between the cables and the surrounding concrete. Pre – tensioned concrete members belong to this class
- **Non- Bonded prestressed concrete:-** is a concrete in which prestress is usually introduced to concrete through anchorage devices and tendons are not bonded to concrete. The tendons are usually placed in the ducts formed in the concrete members.
- **Full prestressing: -** This is a concrete in which tensile stresses in concrete at working loads are completely counter balanced by having sufficiently high prestress
- **Partial prestressing: -** This is a concrete in which tensile stresses in concrete at working loads are partially counter balanced
- **Eccentric prestressing: -** concrete in which the whole of the cross section of the concrete has a uniform compressive priestesses. With this type of prestressing, the tendons run along the centre line of sections.
- **Axial prestressing:-** concrete in which the whole of the cross section of the concrete has a uniform compressive priestesses. With this type of prestressing, the tendons run along the centre line of section.
- **Cracking load: -** this is the load on the structural member corresponding to the first appearance of crack.
- **Characteristic load :-** This is the load which has 95% probability of not being exceeded during the life use or service of the structure
- **Transfer: -** This is the act of transferring the stress in prestressing tendons from the jacks or pretensioning bed to the concrete member.
- **Creep in concrete: -** It is the progressive increase in the inelastic deformation of concrete under sustained stress component.
- **Shrinkage of concrete:-** This is the contraction on drying
- **Degree of prestressing: -** It is a measure of the magnitude of the prestressing force related to the resultant stress occurring in the structural member during working load.
- **Debonding: -** It is the prevention of bond between the steel wire and the surrounding concrete.
- **Relation of steel: -** It is the decrease of stress in stress in steel at constant strain.

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