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Safety Management during Rehabilitation of Structure

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ABSTRACT
This report gives detail information about jacketing and wrapping and overlaying are considered major retrofitting methods for concrete structures. Retrofitting materials used in these methods include reinforced concrete, prestressed concrete, other concrete materials, steel plate, FRP sheet, FRP plate and FRP grid. Retrofitting also plays an important role in foundation.. There are various remedial measures or retrofitting methods that can be utilized against liquefaction and liquefaction-induced lateral spreading for geotechnical structures. In this a promising rehabilitation method was investigated, intended for the retrofitting of existing deep foundation systems. Due to its simplicity, this method can also be also applied during construction of the foundation systems. The retrofitting method isolates the existing shallow nonliquefiable soil layer, which is often major source of damage, from the existing foundation system.

I. INTRODUCTION

What exactly is a retrofit, and how does it differ from a renovation or a tune-up? There are a variety of terms used in the building sector and many of them overlap. Retrofitting is the process of modifying something after it has been manufactured. For buildings, this means making changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation. Typically this is done with the expectation of improving amenities for the building's occupants and/or improving the performance of the building. The development of new technologies mean that building retrofits can allow for significant reductions in energy and water usage. During a refurbishment a building is improved above and beyond its initial condition. Refurbishments are often focused on aesthetics and tenant amenities, but they can also include upgrades to the building's mechanical systems and can potentially have an effect on energy and water efficiency.

Retrofitting an existing building can often times be more cost-effective than building a new facility. Since buildings consume a significant amount of energy, particularly for heating and cooling, and because existing buildings comprise the largest segment of the built environment, it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings. But conserving energy is not the only reason for retrofitting existing buildings. Doing so will mean that the building will be less costly to operate, will increase in value, last longer, and contribute to a better, healthier, more comfortable environment for people in which to live and work. Improving indoor environmental quality, decreasing moisture penetration, and reducing mould all will result in improved occupant health and productivity. Further, when deciding on a retrofit, consider upgrading for accessibility, safety and security at the same time. The unique aspects for retrofit of historic buildings must be given special consideration. Designing major renovations and retrofits for existing buildings to include sustainability initiatives will reduce operation costs and environmental impacts, and can increase building adaptability, durability, and resiliency.

II. NEED OF RETROFITTING

The need to retrofitting of a structure may arise at any time from the beginning of the construction phase until the end of the service life. During the construction phase, it may occur because of:

i. Design errors
ii. Deficient concrete production
iii. Bad execution processes
iv. An earthquake

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v. An accident, such as collisions, fire, explosions
vi. Situations involving changes in the structure functionality

The decision to rehabilitate must be made only after the inspection of the structure, its structural evaluation and a cost/benefit study of the different solutions. Rodriguez Parkpublished extensive bibliographic research on the repair and strengthening of RC structures in seismic areas such as the Balkans, Japan, Mexico, Peru and the USA. Asan example, and related to the cost/benefit analysis, according to the authors, some buildings in Mexico City, repaired and strengthened after the 1985earthquake, had a value between three and four times the operation cost. The choice of the repair and/or strengthening method depends on the structural behavior of objectives.

III. RETROFITTING TECHNIQUES

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.At the stage of selecting the retrofitting method, the current status of the existing structure and its Performance are known and the performance required for the structure after retrofitting and the conditions for retrofitting work are given. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors. This report is mainly focused on Column/Beam Jacketing and Foundation retrofitting.

3.1 Jacketing

Jacketing is the most popularly used method for strengthening of building columns. The most common types of jackets are steel jacket, reinforced concrete jacket, fibre reinforced polymer composite jacket, jacket with high tension materials like carbon fibre, glass fibre etc.The main objective of jacketing is to increase the seismic capacity of the moment resisting framed structures. In almost every case, the columns as well as beams of the existing structure have been jacketed. In comparison to the jacketing of reinforced concrete columns, jacketing of reinforced concrete beams with slabs is difficult yielding good confinement because slab causes hindrance in the jacket. In structures with waffle slab, the increase in stiffness obtained by jacketing columns and some of the ribs, have improved the efficiency of structures. In some cases, foundation grids are strengthened and stiffened by jacketing their beams.An increase in strength, stiffness and ductility or a combination of them can be obtained. Jacketing serves to improve the lateral strength and ductility by confinement of compression concrete. It should be noted that retrofitting of a few members with jacketing or someother enclosing techniques might not be effective enough to improve the overall behaviour of the structure, if the remaining members are not ductile.

3.1.1 Jacketing of Columns

Jacketing of columns consists of added concrete with longitudinal and transverse reinforcement around the existing columns. This type of strengthening improves the axial and shear strength of columns while the flexural strength of column and strength of the beam-column joints remain the same. It is also observed that the jacketing of columns is not successful for improving the ductility. A major advantage of column jacketing is that it improves the lateral load capacity of the building in a reasonably uniform and distributed way and hence avoiding the concentration of stiffness as in the case of shear walls. This is how major strengthening of foundations may be avoided. In addition the original function of the building can be maintained, as thereare no major changes in the original geometry of the building with this technique. The jacketing of columns is generally carried out by following methods:

(i) Reinforced concrete jacketing
(ii) Steel jacketing
(iii) Fibre reinforcement polymer

(i) Reinforced Concrete Jacketing

Table 3.1: Details For Reinforced Concrete Jacketing.(Pravin B. Waghmare)

Properties of jackets	Match with the concrete of the existing structure.
	Compressive strength greater than that of the existing structures by 5 N/mm2or at least equal to that of the existing structure.
Minimum width of jacket	10 cm for concrete cast-in-place and 4 cm for shotcrete.
	If possible, four-sided jacket should be used.
	A monolithic behaviour of the composite column should be assured.
	Narrow gap should be provided to prevent any possible increase in flexural capacity.
Minimum area of longitudinal Reinforcement	3Afy, where, A is the area of contact in cm2 and fy is in kg/cm2
	Spacing should not exceed six times of the width of the new elements (the jacket in the case) up to the limit of 60 cm.
	Percentage of steel in the jacket with respect to the jacket area should be limited between 0.015and 0.04.
	At least, 12 mm bar should be used at every corner for a four sided jacket.
Minimum area of transverse Reinforcement	Designed and spaced as per earthquake design practice.
	Minimum bar diameter used for ties is not less than 10 mm or 1/3 of the diameter of the biggest longitudinal bar.
	The ties should have 135-degree hooks with 10bar diameter anchorage.
	Due to the difficulty of manufacturing 135-degree hooks on the field, ties made up of multiple pieces, can be used.
Shear stress in the interface	Provide adequate shear transfer mechanism to assured monolithic behaviour.
	A relative movement between both concrete interfaces (between the jacket and the existing element) should be prevented.
	Chipping the concrete cover of the original member and roughening its surface may improve the bond between the old and the new concrete.
	For four-sided jacket, the ties should be used to confine and for shear reinforcement to the composite element.
Connectors	Connectors should be anchored in both the concrete such that it may develop at least 80% of their yielding stress.
	Distributed uniformly around the interface, avoiding concentration in specific locations.
	It is better to use reinforced bars (rebar) anchored with epoxy resins of grouts.

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(ii) Steel Jacketing)

Steel plate thickness	At least 6 mm.
Height of jacket	1.2 to 1.5 times splice length in case of flexural columns.
	Full height of column in case of shear columns.
Shape of jackets	Rectangular jacketing, prefabricated two L-shaped panels The use of rectangular jackets has proved to be successful in case of small sizecolumns upto 36 inch width that have been successfully retrofitted with %" thick steel jackets combined with adhesive anchor bolt, but has been less successful on larger rectangular columns. On larger columns, rectangular jackets appear to be incapable t o provide adequate confinement.
Free ends of jackets bottom clearance.	Welded throughout the height of jacket, size of weld1”
	38 mm (1.5 inch) steel jacket may be terminated above the top of footing to avoid any possible bearing of the steel jacket against the footing, to avoid local damage to the jacket and/or an undesirable or unintended increase in flexural capacity.
Gap between steel jacket and concrete column Size of anchor Number of anchor bolts	25 mm fill with cementations grout.
	25 mm in diameter and 300 mm long embedded in 200 mm into concrete column.
	Bolts were installed through pre-drilled holes on the steel jacket using an epoxy adhesive.
	Two anchor bolts are intended to stiffen the steel jacket and improve confinement of the splice.

(iii) Fibre Reinforcement Polymer Jacketing

Several researchers have investigated the possibility and feasibility of fibre reinforced polymer composite jackets for seismic strengthening of columns winding them with high strength carbon fibres around column surface.

The concept involves,

1. Wrapping of RC columns by high strength.
2. Low weight fibre wraps to provide passive confinement, which increases both strength and ductility.
3. FRP sheets are wrapped around the columns, with fibers oriented perpendicular to the longitudinal axis of column, and are fixed to the column using epoxy resin.
4. The wrap not only provides passive confinement and increases the concrete strength, but alsoprovides significant strength against shear

Following are the advantages Fibre Reinforced Polymer:

1. It provides a highly effective confinement to columns.
2. The original size, shape and weight of the members is unaltered (unlike any other
3. jacketing) thus not attracting higher seismic forces.
4. Due to the fact that the original shape and size of the members is practically unaltered, this method is particularly useful for strengthening historic and artistic masonry structures.
5. Due to the orthotropy built in by fiber orientation, the wraps essentially provide only confinement without interfering with the axial load which is taken completely by concrete column as against steel jacketing, where the jacket takes most of the axial load and becomes susceptible to buckling.
6. No drilling of holes is required as against concrete and steel jacketing.

7. The FRPs have extremely good corrosion resistance which makes them high suitable for marine and coastal environments.
8. FRP wraps prevent further deterioration of concrete and inside reinforcement.
9. As the wraps are available in long rolls, construction joints can be easily avoided.
10. Ease of installation, which is similar to putting up wall papers, makes the use of FRP sheets a very cost-effective and efficient alternative in the strengthening of existing buildings.
11. Provides minimal disturbance to existing structure and generally the strengthening work can be performed with normal functioning of structure.

3.1.2 Beam Jacketing

Jacketing of beams is recommended for several purposes as it gives continuity to thecolumns and increases the strength and stiffness of the structure. While jacketing a beam, its flexural resistance must be carefully computed to avoid the creation of a strong beam-weak column system. Below figure 3.4 shows the Beam Jacketing. In the retrofitted structure, there is a strong possibility of change of mode of failure and redistribution of forces as a result of jacketing of column, which may consequentlycauses beam hinging. The location of the beam critical section and the participation of the existing reinforcement should be taken into consideration. Jacketing of beam may be carried out under different ways. The most common are one-sided jackets or 3- and 4-sided jackets. At several occasions, the slab has been perforated to allow the ties to go through and to enable the casting of concrete. The beam should be jacketed through its whole length. The reinforcement has also been added to increase beam flexural capacity moderately and to produce high joint shear stresses. Top bars crossing the orthogonal beams are put through holes and the bottom bars have been placed under the soffit of the existing beams, at each side of the existing column. Beam transverse steel consists of sets of U-shaped ties fixed to the top jacket bars and of inverted U-shaped ties placed through perforations in the slabclosely spaced ties have been placed near the joint region where beam hinging is expected to occur. The mainfeatures of reinforcement details of beam jacketing are given in table. Although those guidelines can give a rational basis for practical design, research still needs to address critical aspects in the behaviour of jacketed elements. The change in behaviour in jacketed elements, whose shear span/depth ratios are significantly reduced, due to their jacketing, needs to be clarified.

Table 3.3: Details of Beam jacketing.(Pravin B. Waghmare)

Minimum width for jacket Longitudinal Reinforcement	8 cm if concrete cast in place or 4 cm for shotcrete
	Percentage of steel on the jacket should be limited to 50 of the total area of the composite section.
Shear reinforcement	Ignore the effect of existing shear reinforcement
	New reinforcement should have 135 hooks and at each corner of the tie there must be at least one longitudinal bar.
	The bar used for the tie should have at least 8 mm diameter
	Multiple piece ties can be used, as discussed before for columns.
Depth of jacketed beam	Span/depth ratio
	Storey height

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	Ductile behaviour

3.2 Foundation Retrofitting

Foundation retrofitting is technique of modifying errors or defects occured in foundation. Following are the methods used in foundation retrofitting.

3.2.1 Underground wall (beam) addition method

Connecting the foundations with cast-in-site diaphragm walls and underground connectingbeams to distribute stress and ensure the stability of the entire system. Below figure 3.5 shows the application of Underground wall (beam) addition method to the foundation.

3.2.2 Foundation improvement method

This method is applied for improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. It also prevents excessive pore water pressure and liquefaction.

IV. CONCLUSION

From the above report it is conclude that the retrofitting of structure is required if damaged is occurred in the structure. Retrofitting of structure is more economical than the rebuilding a structure.

Following conclusions were drawn from the performed work on retrofitting:

1. The retrofitting is a strengthening method, unlike other techniques, leads to increasein strength and stiffness of structure.
2. The durability of the original structure is also improved. All thosereasons make retrofitting an extremely valuablechoice in structural rehabilitation.
3. By using jacketing we can improve the strength of column,beam and other structural element
4. By the application of foundation Retrofitting also increase the strength and bearing capacity of damage structure and existing structure.

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