BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 66 (70), Numărul 1, 2020
Secția
CONSTRUCȚII. ARHITECTURĂ

# DESIGN AND ANALYSIS OF BARBELL TYPE CONCRETE WALL

BY

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Received: February 14, 2020
Accepted for publication: March 20, 2020

**Abstract.** Barbell type concrete wall is a typical section of designing concept for reinforcement curtailments and seismic failure of required ranges of magnitudes. It is resolve meet architectural concepts and as well as configuration of high raise buildings. Concrete wall improper design reinforcement arrangement is sudden failure in earthquakes disasters. Most of the analysis evaluation based on analytical wise possible otherwise not applications systems. But these paper fully evaluate updated design and of correct reinforcements curtailment in barbell type concrete walls.

**Keywords:** design parameters; axial load combinations; section design; footing design.

## 1. Introduction

Barbell type concrete wall is a shear wall its consists of 2-sides bells like concrete structures (David Ugalde, 2017) evaluate the structural frames are the proposed in earthquake region its they where are sporadically provide combined with steel braced and concrete wall. The observation developments of

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most high rise buildings reanalyzed using in actual elastic theory are applied in a flexural capacity of concrete wall computed by fiber model, depends upon the earthquake capacity. The impact of monolithic concrete wall is higher value of shear capacity investigated by (Hoenderkamp, 2011). Incalculable ranges of earthquakes shows to learning the fundamental shear mechanisms of concrete wall. The typical reinforcement of concrete walls are undergoes shear as a ultimate way of loadings and based on their dimensions, be classified into 2-types lofty rise and short rise concrete wall (Bekő, 2015). Design engineers have been required to design the vertical structures with dissimilar structural system for example moment resistance structure and concrete wall frames system structure (Astriana, 2017) Investigates staging complicated earthquake performances of moment resistivity frames as balanced to concrete wall structure framed systems. Lightly reinforced design of concrete walls are not performed for seismic actions that types of framed works earthquake evaluations of existing of structures (Grifenhagen, 2005) observation of light reinforced concrete walls shear failures is limited and significant of ultimate load test result is not affected that the lateral reinforcement of wall. Xiaodong Ji, (2012) proposed an barbell types sections of concrete composite wall that was compute with eccentric sides edge columns is highly deformation capacity compared to the normal rectangular shape concrete composite walls. In used to additional clarify formulation applied to asses the horizontal load load carrying capacity of the reinforced composite shear wall. Hossain *et al.*, (2016), studied the advantages of using a Mild yield steel bars reinforcement concrete is indicated high ductile failure. In cyclic loading behavior of shear wall is high peak load deformed the ultimate shear, compared to other conventional components that concrete wall, (80%) high energy absorption capacity and not with standing lower compressive concrete strength. The concrete structural walls was distributed the lateral loads, in effectively resists the such as seismic or wind in high rise building (Shahrooz, 2000). Nunziante Valoroso, (2014), say as additionally concrete walls is existing the structural elements systems its resists the effectively actions transmitted for tangential impact load by the adjacent structural frame component fragments. ACI Committee 318, (2011), proposed by new construction materials and techniques put the shear wall constructions practiced is a possibility for safety under earthquake incident. Aspects of construction of cost is reductions and inspiring the environmental conservations, action and continuity. Single and two storey building concrete wall designed thickness is 100mm and used 15 and 20 N/mm2 compressive strength of concrete. And compressed quasic static cyclic test and 20 walls vibration test are conducted and seismic performances of light reinforced slender concrete shear walls experimentally by Carrillo, (2015). Hoederkamp, (2011), examined the non coupled shear walls structures (or) singular planar walls decreasing the major bending moment and coupled shear wall otherwise multi shear wall structure are increasing the degree of coupling, it means inter connectivity of the walls in building plans. Josephs Kiefer shear walls is dissimilar reinforcement arrangement is balanced gravity load under the quasi static cyclic loading, concrete shear wall design is some additional reinforced bars provided in a stiffener section. JK shear wall can sustained ductility propertys its request the steer by the causing loops (Bahrami-Rad, 2014). Gupta, (1984), modeling of shear wall building such concrete shear wall described shear lag occurrence its affected the stiffness due to bending and stress distribution in the gross area of the building. Stress deformation application of wall have been both the ≤ 3.5 m and < 3.5 m height.

## 2. Methodology

### 2.1. Design Parameters

The governing non-dimensional parameters of the limit state design compression member in a structural system is defines as follows:

$$P_u/f_{ck}bd, \tag{1}$$

$$M_u/f_{ck}bD^2, \tag{2}$$

where: $f_{ck}$ is a characteristic strength of the concrete. Related with the non-dimensional parameters, ($f_{ck}$) as the does not improved the grade of concrete strength. Refer the design chart of SP-16 and set assume the constant value of grade in steel and concrete (Fe 250, 415, 500 and 550).

Longitudinal reinforcement refer chart SP-16 and read out ratio of

$$(\mathrm{p}/\mathrm{f}_{\mathrm{ck}}). \tag{3}$$

Therefore

$$P = \{(p/f_{ck}) \times \text{Grade of concrete}\}, \tag{4}$$

$$\text{and area of Steel}=\{pbd/100\}, \tag{5}$$

- And after identified Asc value to calculate the numbers of primary reinforcement rods and diameters rods.
- Lateral ties diameter of rod is (¼) × Main Diameter of rods, Lateral ties spacing is adopted in ≥ 300 mm.

The reinforced concrete wall are intended to carry vertical load they should be designed generally in accordance with recommendation given for columns. Provision of traverse reinforcement to restrained the vertical bars that its resists heavy vertical load and buckling effect. The minimum thickness of concrete shear not less than 150 mm. load carrying capacity for barbell type concrete wall has should be calculated as for concrete columns, strength of wall is depend upon the height of storey of building.

**Table 1**

*Identical Required Value of Dimension in Reinforced Concrete Wall*

| Ratio of Storey height to length of concrete wall | 1.5m or more | 3.5m or less |
|---|---|---|
| % increased in strength | 0 | 20 |

Slenderness effective height of wall exceed 12 times the wall thickness, slenderness effect mostly considered the concrete columns, the slenderness effect of concrete wall has stiffened. The reinforcement for barbell type concrete wall is provided minimum not longer than 16mm diameter for main reinforcement bars and characteristics strength of 415 or above grade of steel must be design provided. The vertical and horizontal reinforcement of spacing should be provided not more than 350 to 400 mm. The minimum reinforcement are more sufficient and improved the ductility friction bond strength into the concrete and steel.

**2.2. Design Parameter for Footing Design for Barbell Type Concrete Wall**

Reinforced barbell type concrete wall footing design is separation of sections. And finally anchored to interlock to vertical and traverse reinforcement with proper spacing. It will first defined the depth of footing for moment considerations:

$$M_u = 0.138 f_{ck}\, bd^2 \quad (6)$$

$d = \sqrt{(M_u/(0.138 f_{ck} b))}$, From shear consideration for critical section one way is located at a distance $d$ from the face of the each supporting section of concrete wall. Assuming the shear strength of $\iota_c$ depend upon the grade of concrete and nominal percentage of reinforcement $P_t$:

$$\iota_c = V_{ul}/(bd). \quad (7)$$

Adopting the effective depth and overall depth of Footing design. And after determined the reinforcement in footing along the section. The concept of reinforcement footing detailing in barbell type shear wall is longer direction and shorter direction required rectangular wall section and designed area of steels provided at the diameter of bars (≤ 16mm). check for shear stress in longer directions Ast, and refer the table Indian standard 456-2000 check the permissible shear stress and nominal shear stress $\{\iota_v > (k_s \iota_c)\}$.

### 2.3. Load cases and Combinations

The applicable load cases and combination are determined the materials accordance ACI and IS code standards.

**Table 2**
*Axial Load and Bending Moments*

| Load cases | Axial Loads |
|---|---|
| Dead load (P) | 2,000 KN |
| Roof live load | Roof with access (8 KN) accordance with ACI |
| Floor live loads | 1,779.29 KN |

## 3. Numerical Examples Design Modeling

Example based designed for 4 Storey commercial building reinforced barbell type concrete wall of cross sectional dimensions 500 mm by 500 mm stiffener sections and central part of stem wall dimensions is 300 mm by 1,000 mm design M-25 grade concrete and Fe-500 HYSD bars.

### 3.1. Stiffener Section Design

Longitudinal reinforcements:

$$P_u = 0.4 f_{ck} A_g + [0.67 f_y - (0.4 f_{ck})] A_{sc}, \tag{8}$$

$2{,}000 \times 10^3$ (Table2) $= 0.4 \times 25 \times (500) \times 2 + [0.67(500)(0.4 \times 25)]A_{sc}$
$A_{sc} = 500 \times 10^3/325 = 1{,}538.46$ mm$^2$, ($A_{sc}$ value/required diameter bars). Provided 8 numbers of rods and 16mm diameter bars. Spacing is ($10^3$xArea of single rod/$A_{sc}$), available spacing is 130.6 ≈ 135 mm. Lateral ties bars diameter {(1/4) × 16 = 4 mm ≈ ≈ 8mm}, Ties spacing is provided in 150 mm to 250 mm accessible ranges (Fig. 1).

### 3.2. Stem Wall Section Design

As well as same procedure appealing of longitudinal reinforcement $P_u =$ $= 2{,}000 \times 10^3$ N, $f_{ck} = 25$ N/mm$^2$, $f_y = 500$ N/mm$^2$.

Asc = 754.72 mm$^2$, Provided 7 numbers of bars and each bars 12mm diameters at spacing is {($10^3 \times 113.09$)/754.72} = 150 mm c/c. and lateral ties bars diameter {(1/4) × 12 = 3 mm ≈ 8 mm}, Ties spacing is provided in 250 mm c/c (Fig. 1).

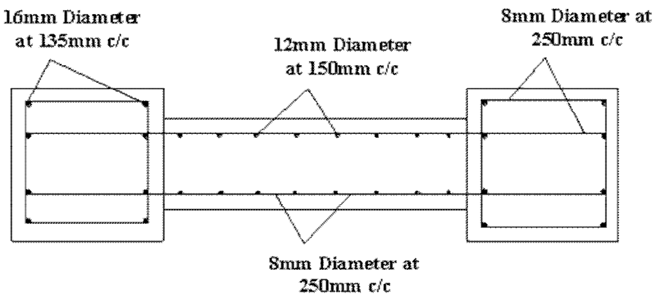


Fig. 1 − Details of reinforcements in the barbell type concrete wall section.

Represented Fig. 1 is section wise separate to designs, and finally interlock to the all sections parts for barbell type concrete wall. Practically interlocking links bars is bend anchorage connections fixed to tie primary rods.

### 3.3. Footing Design

Stiffener portion of footing area is wall load divided by factored bearing capacity of soil. Dead load footing = 10% × 2,000 KN (Table 2)/100, 200 KN + + 2,000 KN = 2,200 KN, Footing area is 25 m$^2$. Proportion the footing area in the same proportion as the side of the stiffener. Including the all side footing areas = 25 m$^2$.

Traverse Side of stiffener footing = 1.6 ≈ 2.5 m

$$\text{Bending moment} = 0.5 P_u L^2, \quad (9)$$

$L = 0.5(5 - 0.5)$;
$M_u = 562.5$ KN.m;
$d = (562.5 \times 10^6 / 0.138 \times 25 \times 10^3)0.5 = 403$ mm.

Assume shear strength of $\iota_c = 0.36$ N/mm$^2$ for M-25 grade concrete with nominal percentage of reinforcement, $p_t = 25\%$. Adopted effective depth d is 550 mm and $D$ = 600 mm, 50 mm concrete cover. Reinforcement in directions.

$M_u = (0.87 f_y A_{st} d)[1 - (A_{st} f_y / bdf_{ck})]$ or 0.12% × cross section dimensions. (10)

$A_{st}$ = 2,178.532 mm$^2$,using 16mm diameter twisted bars at 100 mm c/c and provide 11 numbers of bars. Stem wall sections of footing area 25m$^2$, long side footing length is 10m, Short side footing is 2.5 m. Adopted a rectangular footing of size 10 m × 2.5 m. Factored of soil pressure, $p_u$ = 800 KN/m$^2$. Cantilever projection of Y-axis or short side direction of each face of the barbell section is 1m and Cantilever projection of X-axis or long side direction of each face of the Barbell wall sections is 4 m. Bending moment short side face $0.5p_uL^2$ = = 400 KN.m, Bending moment long side face is 25 KN.m, $d$ = 450 mm, $D$ = = Clear cover(50 mm) + 450 mm. Depth of the footing is 500mm.

Reinforcement along longer directions

Needable of 16 mm diameter rods, adopted spacing is 250 mm c/c, provided 40 numbers rods required.

Reinforcement along shorter directions

Needable of 12 mm diameter rods, spacing is 250 mm c/c, provided 25 numbers rods required.

Check shear stress

$\tau_{c\ (max)}$ = 3.1 N/mm$^2$ Maximum shear strength M-25 Grade concrete (refer table 19 IS 456-2000). Nominal shear stress $\tau_v$ = 0.33 N/mm$^2$ ($\tau_{c\ (max)}$ = 3.1 > $\tau_v$).

Shear stress are within the safe permissible limits.

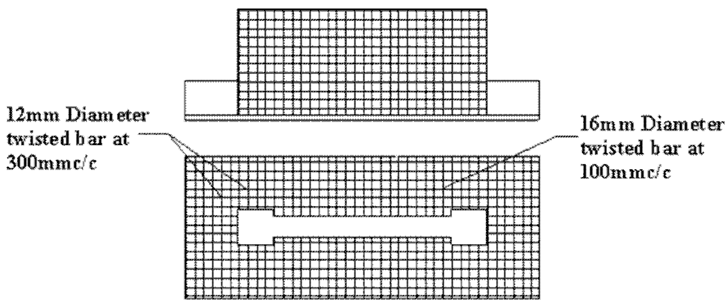


Fig. 2 − Details of reinforcements in the barbell type concrete wall footing Section.

## 4. Conclusion

The design concept for barbell type concrete wall is strongly resists the lateral impact load without failures and improvements of ductility property of the buildings. That analysis of designed in a each part sections and interlocked connections with secondary reinforcement that motion improvement of frictions strength of each sections rod curtailments. It sit suggested preferred by the three storey residential and commercial building in seismic prone zone areas.

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PROIECTAREA ŞI ANALIZA PERETELUI CONCRET DE TIP BARBELL

(Rezumat)

Peretele de beton tip Barbell este o secțiune tipică a conceptului de proiectare pentru reducerile de armare şi defecțiunea seismică a intervalelor de mărimi necesare. Este rezolvarea îndeplinirii conceptelor arhitecturale, precum şi configurarea clădirilor ridicate. Amenajarea necorespunzătoare a zidului de beton este o defecțiune bruscă în dezastrele cutremurelor. Cea mai mare parte a evaluării analizei este bazată pe înțelepciunea analitică posibil, altfel nu în sistemele de aplicații. Dar aceste lucrări evaluează pe deplin designul actualizat şi reducerea corectă a armăturilor în pereții de beton de tip baril.