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Design and Analysis of Multistory Building in Staad Pro

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ABSTRACT

A multi storey building is a building that has multiple floors above ground in the building. Multi-storey buildings aim to increase the floor area of the building without increasing the area of the land and saving money. Analysis of multi-storey building frames involves lot of complications and edacious calculations by conventional methods. To carry out such analysis is a time consuming task. Substitute frame method for analysis can be handy in approximate and quick analysis instead of bidding process. Till date, this method has been applied by designers for vertical loading conditions. The represented plan given to office purposes can accommodate with minimum facilities. Generally buildings may be failed by bending moments, shear forces acting on members of the building. By keeping these failures in mind, we designed beams, columns, footings by considering maximum loads on members. For loads calculation, substitute frame method is used for reducing the complexity of calculations and saving time. We know R.C structural system are most common nowadays in urban regions with multi-bay and multi-storeys, keeping its importance in urban regions especially, A building frame consists of number of bays and storey. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+5 storey frame work is taken up. The building in plan (6.66m * 8.9m) consists of columns built monolithically forming a network.

The design is made using software on structural analysis design (staad-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and wind load as **per IS 875**. The building is designed as two-dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per **IS456-2000**. The help is taken by software available in institute and the computations of loads, moments and shear forces and obtained from this software.

INTRODUCTION

1.1. GENERAL

Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof,food, cloth and the basic needs of human beings. In the early ancient times humans lived incaves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated

condition houses.Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person do utmost effort and spend hard earned saving in owning houses.

Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout, etc, of the buildings. Draughtsman are responsible for doing the drawing works of building as for the direction of engineers and architects. The draughtsman must know This job and should be able to follow the instruction of the engineer and should be able to draw the required drawing of the building, site plans and layout plans etc, as for the requirements.

A building frame consists of number of bays and storey. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+5 storey frame work is taken up. The building in plan (6.66m * 8.9m) consists of columns built monolithically forming a network.

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EARLY MODERN AND THE INDUSTRIAL AGE:

With the emerging knowledge in scientific fields and the rise of new materials and technology, architecture engineering began to separate, and the architect began to concentrate on aesthetics and the humanist aspects, often at the expense of technical aspects of building design.

Meanwhile, the industrial revolution laid open the door for mass production and consumption. Aesthetics became a criterion for the middle class as ornamental products, once within the province of expensive craftsmanship, became cheaper under machine production. Vernacular architecture became increasingly ornamental. House builders could use current architectural design in their work by combining features found in pattern books and architectural journals.

Modern architecture:

The Bauhaus Dessau architecture department from 1925 by Walter Gropius. The dissatisfaction with such a general situation at the turn of the 20th century gave rise to many new lines of thought that served as precursors to modern architecture. Notable among these is detachers' deskbound, formed in 1907 to produce better quality machine made objects. The rise of the profession of industrial design is usually placed here. Following this lead, the Bauhaus school, founded in Weimar, Germany in 1919, redefined the architectural bounds prior set throughout history viewing the creation of a building as the ultimate synthesis—the apex—of art, craft and technology.

When modern architecture was first practiced, it was an avant-garde moment with moral, philosophical, and aesthetic underpinning. Immediately after world war I, pioneering modernist architects sought to develop a completely new style appropriate for a new post-war social and economic order, focused on meeting the needs of the middle and working classes. They rejected the architectural practice of the academic refinement of historical styles which served the rapidly declining aristocratic order.

LITERATURE REVIEW

Sreeshna K.S (2016) this paper deals with structural analysis and design of Multistoried apartment building. The work was completed in three stages. The first stage was modeling and analysis of building and the second stage was to design the structural elements and the final was to detail the structural elements. In this project STAAD. Pro software is used for analysing the building. The IS:875 (Part 1) and (Part 2) were referred for dead load and live load. Design of structural elements like beam, column, slab, staircase, shear wall, retaining wall, pile foundation is done according to IS Codes. Aman et al., (2016) has discussed that the aim of the structural engineer is to design a safe structure. Then the structure is subjected to various types of loading. Mostly the loads applied on the structure are considered as static. Finite part analysis that exhibit the result of dynamic load like wind result, earthquake result, etc. The work is conducted using STAAD. Pro software.

Madhurivassavai et al., (2016) he says that the one of the major problem country facing is the growing population. Because of the less availability of land, multi-storey building can be constructed to serve many people in limited area. Efficient modelling is performed using STAAD. Pro and AutoCAD. Manual calculations for high rise buildings are tedious and time consuming. STAAD. Pro provides us a quick, efficient and correct platform for analysing and coming up with structures.

PLAN AND LOADINGS

3.1. PLAN:

The auto cad plotting no.1 represents the plan of a g+6 building. The plan clearly shows that it is a combination of four apartments. We can observe there is a combination between each and every apartments.

In each block the entire floor consists of a double-bed room house which occupies entire floor of ablock. It represents a rich locality with huge areas for each house. It is a g+6 proposed building.

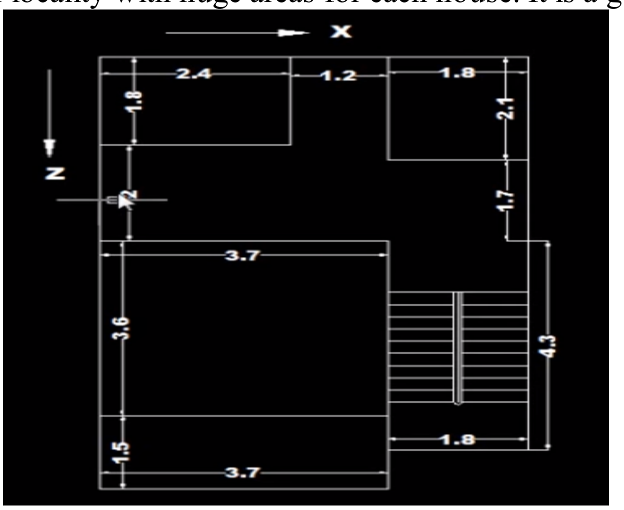


Fig.: 3.1. Plan of building

Figure 3.2a Elevation of the building

3.2. **LOAD CONDITIONS AND STRUCTURAL SYSTEM RESPONSE:**

The concepts presented in this section provide an overview of building loads and their effect on the structural response of typical wood-framed homes. As shown in Table, building loads can be divided into types based on the orientation of the structural action or forces that they induce: vertical and horizontal (i.e., lateral) loads. Classification of loads are described in the following sections.

3.2.1. Building Loads Categorized by Orientation:

Types of loads on an hypothetical building are as follows.

- Vertical Loads
- Dead (gravity)
- Live (gravity)
- Snow(gravity)
- Wind(uplift on roof)
- Seismic and wind (overturning)
- Seismic(vertical ground motion)

3.2.2. Horizontal (Lateral) Loads:

Direction of loads is horizontal w.r.t to the building.

- Wind
- Seismic(horizontal ground motion)
- Flood(static and dynamic hydraulic forces
- Soil(active lateral pressure)

- **Vertical Loads :**

Gravity loads act in the same direction as gravity (i.e., downward or vertically) and include dead, live, and snow loads. They are generally static in nature and usually considered uniformly distributed or concentrated load. Thus, determining a gravity load on a beam or column is a relatively simple exercise that uses the concept of tributary areas to assign loads to structural elements, including the dead load (i.e., weight of the construction) and any applied loads (i.e., live load). For example, the tributary gravity load on a floor joist would include the uniform floor load (dead and live) applied to the area of floor supported by the individual joist. The structural designer then selects a standard beam or column model to analyze bearing connection forces (i.e., reactions) internal stresses (i.e., bending stresses, shear stresses, and axial stresses) and stability of the structural member or system a for beam equations.

The selection of an appropriate analytic model is, however no trivial matter, especially if the structural system departs significantly from traditional engineering assumptions are particularly relevant to the structural systems that comprise many parts of a house, but to varying degrees. Wind uplift forces are generated by negative (suction) pressures acting in an outward direction from the surface of the roof in response to the aerodynamics of wind flowing over and around
the building. As with gravity loads, the influence of wind up lift pressures on a structure or assembly (i.e.,roof) are analyzed by using the concept of tributary areas and uniformly distributed loads. The major difference is that wind pressures act perpendicular to the building surface (not in the direction of gravity) and that pressures vary according to the size of the tributary area and its location on the building, particularly proximity to changes in geometry (e.g., eaves, corners, and ridges).Even though the wind loads are dynamic and highly variable, the design approach is based on a maximum static load (i.e., pressure) equivalent. Vertical forces are also created by overturning reactions due to wind and seismic lateral loads acting on the overall building and its lateral force resisting systems, Earthquakes also produce vertical ground motions or accelerations which increase the effect of gravity loads. However, Vertical earthquake loads are usually considered to be implicitly addressed in the gravity load analysis of a light-frame building.

- **Lateral Loads:**

The primary loads that produce lateral forces on buildings are attributable to forces associated with wind, seismic ground motion, floods, and soil. Wind and seismic lateral loads apply to the entire building. Lateral forces from wind are generated by positive wind pressure son the windward face of the building and by negative pressures on the leeward face of the building, creating a combined push and-pull effect. Seismic lateral forces are generated by structure's dynamic inertial response to cyclic ground movement.

The magnitude of the seismic shear (i.e., lateral)load depends on the magnitude of the ground motion, the buildings mass, and the dynamic structural response characteristics (i.e., dampening, ductility, natural period of vibration, etc.). for houses and another similar low rise structures, a simplified seismic load analysis employs equivalent static forces based on fundamental Newtonian mechanics(F=ma) with somewhat subjective(i.e., experience-based)adjustments to account for inelastic, ductile response characteristics of various building systems.

Flood loads are generally minimized by elevating the structure on a properly designed foundation or avoided by not building in a flood plain. Lateral loads from moving flood waters and static hydraulic pressure are substantial. Soil lateral loads apply specifically to foundation wall design, mainly as an "out-of-plane" bending load on the wall. Lateral loads also produce an overturning moment that must be offset by the dead load and connections of the building. Therefore, overturning forces on connections designed to restrain components from rotating or the building from overturning must be considered.

Since wind is capable of the generating simultaneous roof uplift and lateral loads, the uplift component of the wind load exacerbates the overturning tension forces due to the lateral component of the wind load. Conversely the dead load may be sufficient to offset the overturning and uplift forces as is the case in lower design wind conditions and in many seismic design conditions.

3.3. Structural systems:

As far back as 1948, it was determined that "conventions in general use for wood, steel and concrete structures are not very helpful for designing houses because few are applicable" (NBS,1948). More specifically, the NBS document encourages the use of more advanced methods of structural analysis for homes. Unfortunately. the study in question and all subsequent studies addressing the topic of system performance in housing have not led to the development or application of any significant improvement in the codified design practice as applied to housing systems. This lack of application is partly due to conservative nature of the engineering process and partly due to difficulty of translating the results of narrowly focused structural systems studies to general design applications. Since this document is narrowly scoped to address residential construction, relevant system

Based studies and design information for housing are discussed, referenced, and applied as appropriate. If a structural member is part of system, as it typically the case in light frame residential construction, its response is altered by the strength and stiffness characteristics of the system as a whole. In general, system performance includes two basic concepts known as load sharing and composite action. Load sharing is found in repetitive member systems(i.e., wood framing) and reflects the ability of the load on one member to be shared by another or, in the case of uniform load, the ability of some of the load on a weaker member to be carried by adjacent members. Composite action is found in assemblies of components that, when connected to one another, from a "composite member" with greater capacity and stiffness than the sum of the component parts.

Design loads for residential buildings :

General

Loads are a primary consideration in any building design because they define the nature and magnitude of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life. The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (sizeand shape) and location (climate and site conditions). Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration.

Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically. While the buildings considered in this guide are primarily single-family detached and and attached dwellings, the principles and concepts related to building loads also apply to other similar types of construction, such as low-rise apartment buildings. In general, the the design loads recommended in this guide are based on applicable provisions of the ASCE 7 standard-Minimum Design ;loads for buildings and other structures(ASCE,1999).the ASCE 7 standard represents an acceptable practice for building loads in the United states and is recognized in virtually all U.S. building codes. For this reason, the reader is encouraged to become familiar with the provisions, commentary, and technical references contained in the ASCE 7 standard.

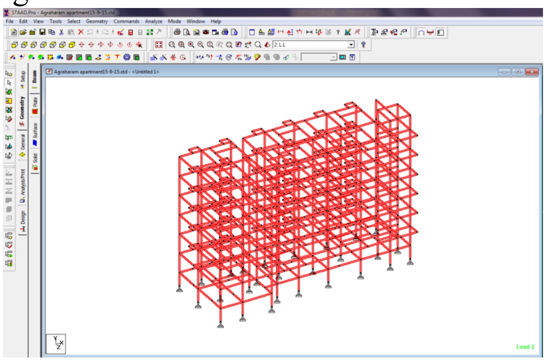
In general structural design of housing has not been treated as a unique engineering discipline or subjected to a special effort to develop better, more efficient design practices. Therefore, this part of the guide focuses on those aspects aspects of ASCE 7 and other technical resources that are particularly relevant to the determination of design loads for residential structures.

The guide provides supplemental design assistance to address aspects of residential construction where current practice is either silent or in need of improvement. Residential buildings methods for determining design loads are complete yet tailored to typical residential conditions. as with any design function, the designer must ultimately understand and approve the loads for a given project as well as the overall design methodology, including all its inherent strengths and weakness.

Since building codes tend to vary in their treatment of design loads the designer should, as a matter of due diligence, identify variances from both local accepted practice and the applicable code relative to design loads as presented in this guide, even though the variances maybe considered technically sound. Complete design of a home typically requires the evaluation of several different types of materials. Some material specifications use the allowable stress design (ASD) approach while others use load and resistance factor design (LRFD).

- **Dead Loads:**

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc.
In staad pro assignment of dead load is automatically done by giving the property of the member. In load case we have option called self weight which automatically calculates weights using the properties of material i.e., density and after assignment of dead load the skeletal structure looks red in color as shown in the figure.



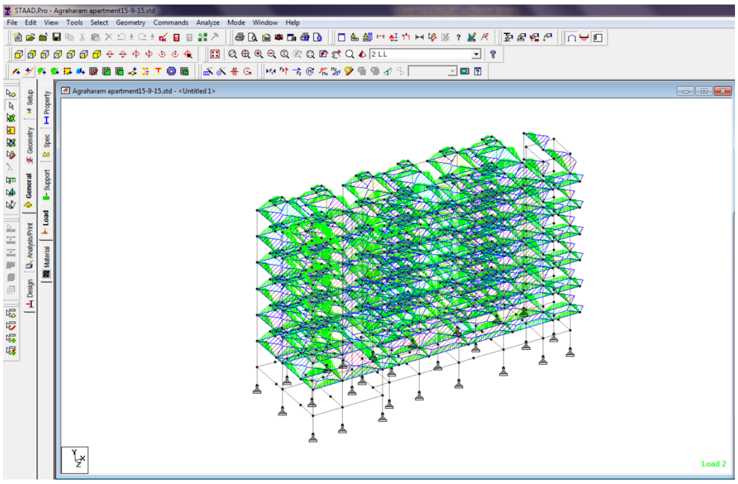
Dead load calculation:

Weight=Volume x Density
Self weight floor finish=0.12*25+1=3kn/m^2
The above example shows a sample calculation of dead load.

- **Live Loads:**

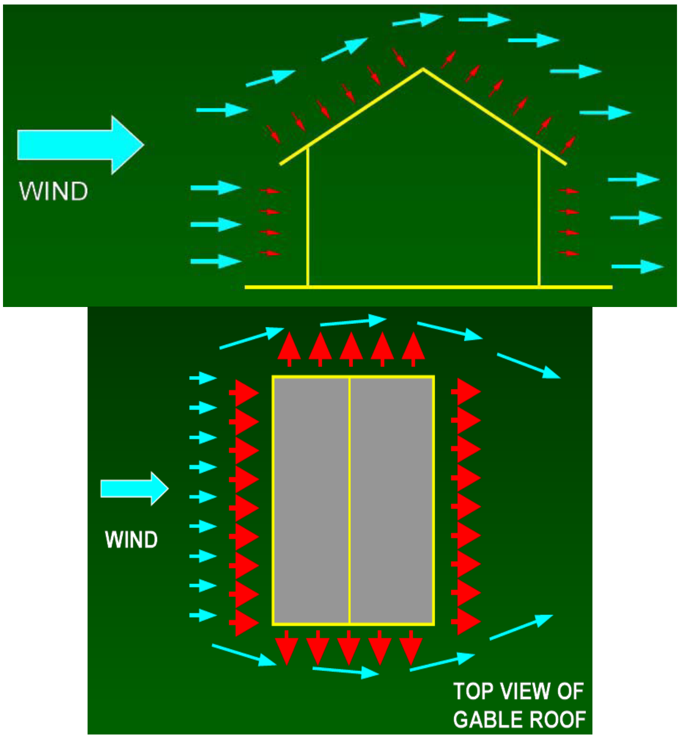
Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously n a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in endues conditions. For example. The stair load of 300 pounds should be applied to the center of the stair tread between supports.

In staad we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. After the assignment of the live load the structure appears as shown below.
For our structure live load is taken as **25 N/mm** for design.
Live loads are calculated as per **IS 875 part 2**



- **Wind loads:**

In the list of loads we can see wind load is present both in vertical and horizontal loads. This is because wind load causes uplift of the roof by creating a negative(suction) pressure on the top of the roof.



A diagram of wind load

wind produces non-static loads on a structure at highly variable magnitudes. the variation in pressures at different locations on a building is complex to the point that pressures may become too analytically intensive for precise consideration in design. Therefore, wind load specifications attempt to amplify the design problem by considering basic static pressure zones on a building representative of peak loads that are likely to be experienced. The peak pressures in one zone for a given wind direction may not, However, occur simultaneously in other zones. For some pressure zones, The peak pressure depends on an arrow range of wind direction. Therefore, the wind directionality effect must also be factored into determining risk consistent wind loads on buildings.

After designing wind load can be assigned in two ways

1. collecting the standard values of load intensities for a particular heights and assigning of the loads for respective height.
2. calculation of wind load as per **IS 875 part 3.**

We designed our structure using second method which involves the calculation of wind load using wind speed.

3.4.1. <u>Basic wind speed:</u>

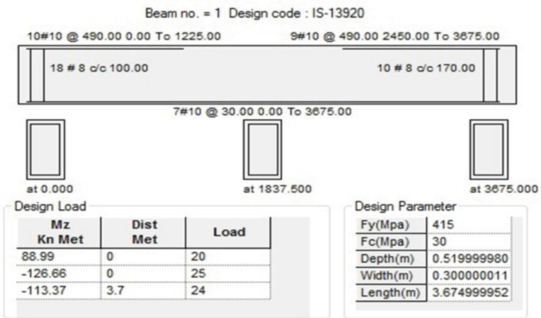
Gives basic wind speed of India, as applicable to 1m height above means ground level for different zones of the country. Basic wind speed is based on peak just velocity averaged over a short time interval of about 3 seconds and corresponds to mean heights above ground level in an open terrain. The wind speed for some important cities/towns is given table below.

CITIES SPEED	BASIC WIND (m/s)	CITIES SPEED	BASIC WIND (m/s)
Cuttack	50	Pune	39
Agra	47	Jhansi	47
Durbhanga	55	Raipur	39
Ahmadabad	39	Jodhpur	47
Darjeeling	47	Rajkot	39
Ajmer	47	Kanpur	47
Dehra dun	47	Ranchi	39
Alomar	47	Kohima	44
Delhi	47	Roorkee	39
Amritsar	47	Kurnool	39
Alanson	47	Rourkela	39
Gangtok	47	Lakshadweep	39
Auragabad	39	Simla	39
Gauhati	50	Srinagar	39
Bahraich	47	Ludhina	47
Gaya	39	Surat	44
Bangalore	33	Madras	50
Gorakhpur	47	Tiruchchirappalli	47
Varanasi	47	Madurai	39
Hyderabad	44	Trivandrum	39
Bareilly	47	Mandi	39
Impale	47	Udaipur	47
Bhatinda	47	Mangalore	39
Jabalpur	47	Vododara	44
Bhalali	39	Moradabad	47
Jaipur	47	Varanasi	33
Bhopal	39	Mysore	50
Jamshedpur	47	Vijayawada	50
Bhuvaneshwar	50	Nagpur	44
Bhuj	50	Vishakhapatnam	50
Bikaner	47	Naimital	47
Bikaro	47	Nasik	39
Bokaro	47	Nellore	50
Bombay	44	Panjim	39
Calcutta	50	Patiala	47

- **<u>Floor load:</u>**

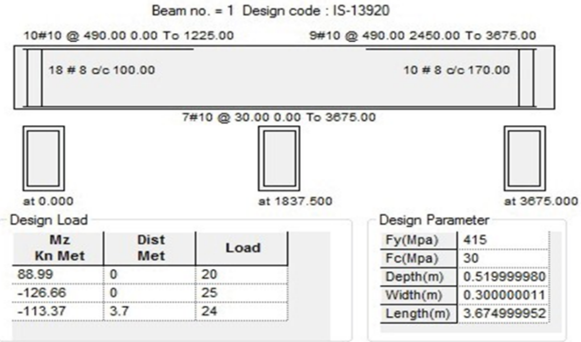
Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure.
The intensity of the floor load taken is: **0.0035 N/mm2**
-ve sign indicates that floor load is acting downwards.

I. EXPERIMENT AND RESULT



I.

II. EXPERIMENT AND RESULT



III.

Beam Design:

EUDL CONSIDERED ON MEMBER # 1 IS 20.61 N/MM.

=== B E ANM N O. 1

D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3675.0 mm SIZE: 300.0 mm X 520.0 mm COVER: 25.0 mm SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 918.8 mm 1837.5 mm 2756.2 mm 3675.0 mm

- -

TOP 779.62 465.63 465.63 465.63 688.30

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) BOTTOM

531.57 465.63 465.63 465.63 465.63

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

- -

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT SHEAR DESIGN RESULTS AT 710.0 mm AWAY FROM START SUPPORT

VY = 79.02 MX = -0.46 LD= 25

Provide 2 Legged 8í @ 170 mm c/c

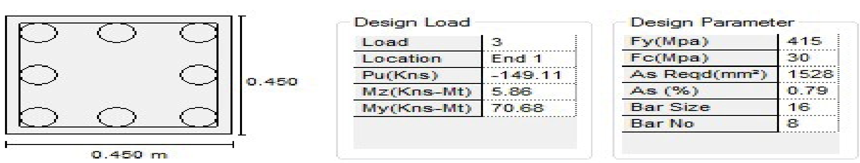
SHEAR DESIGN RESULTS AT 710.0 mm AWAY FROM END SUPPORT VY = -80.37 MX = 0.10 LD= 24

Provide 2 Legged 8í @ 170 mm c/c

EUDL CONSIDERED ON MEMBER # 2 IS 20.47 N/MM.

Column Design:

Beam no. = 31 Design code : IS-13920



COLUMN DESSIGN

=== C O L U M N N O. 31

D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 4000.0 mm CROSS SECTION: 450.0 mm X 450.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 3 END JOINT: 1 SHORT COLUMN REQD. STEEL AREA : 1528.10 Sq.mm.
REQD. CONCRETE AREA: 191013.05 Sq.mm.
MAIN REINFORCEMENT : Provide 8 - 16 dia. (0.79%, 1608.50 Sq.mm.)
(Equally distributed)
CONFINING REINFORCEMENT : Provide 12 mm dia. rectangular ties @ 100 mm c/c
Over a length 670.0 mm from each joint face towards Midspan as per Cl. 7.4.6 of IS-13920. 2 number overlapping hoop along with crossties are provided along Y direction. (Clause 7.3.2 of IS-13920) 2 number overlapping hoop along with crossties are provided along Z direction. (Clause 7.3.2 of IS-13920)
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 225 mm c/c SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
Puz : 3188.74 Muz1 : 78.22 Muy1 : 78.22 INTERACTION RATIO: 0.98 (as per Cl. 39.6, IS456:2000)
SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET) WORST LOAD CASE: 3
END JOINT: 1 Puz : 3212.68 Muz : 82.82 Muy : 82.82 IR: 0.92

	= 0.04766
Moment Co-efficient in longer dir. at span , α_y	= 0.03500
Moment Co-efficient in longer dir. at edge , α'_y	= 0.04700
Factored Moment at ,	
Span in shorter direction , M_{ux} $= \alpha_x * W * L_x^2$	= 6616.82975 Nmm
Span in longer direction , M_{uy} $= \alpha_y * W * L_x^2$	= 6514.12673 Nmm
Support in shorter direction , M'_{ux} $= \alpha'_x * W * L_x^2$	= 8870.78524 Nmm
Support in longer direction , M'_{uy} $= \alpha'_y * W * L_x^2$	= 8747.54162 Nmm
Width of the Slab , b	= 1 mm
Limiting Moment of resistance of section	
Along X-Direction , $M_{u,lim-x}$	= 24902.41494 Nmm
Along Y-Direction , $M_{u,lim-y}$	= 20407.56354 Nmm
Area Of steel reinf. in X-Dir. at span bottom , A_{stx}	= 0.20181 sq. mm
Area Of steel reinf. in Y-Dir. at span bottom , A_{sty}	= 0.22165 sq. mm
Area Of steel reinf. in X-Dir. at support top , A'_{stx}	= 0.27516 sq. mm
Area Of steel reinf. in Y-Dir. at support top , A'_{sty}	= 0.30402 sq. mm
Minimum Area Of steel reinf. in X-Dir. , $A_{stx-min}$	= 0.14400 sq. mm
Minimum Area Of steel reinf. in Y-Dir. , $A_{sty-min}$	= 0.14400 sq. mm
Cross-sectional Area Of steel in X-Dir. , $A\phi_x$ $= \pi * \phi_x^2/4$	= 78.53975 sq. mm
Cross-sectional Area Of steel in Y-Dir. , $A\phi_y$ $= \pi * \phi_y^2/4$	= 50.26544 sq. mm
Spacing in shorter Dir. at span , S_x	= 280.000 mm
Spacing in longer Dir. at span , S_y	= 220.000 mm
Maximum Spacing in shorter Dir. , S_{x-max}	= 280.000 mm
Maximum Spacing in longer Dir. , S_{y-max}	= 250.000 mm
Spacing in shorter direction at edge , S'_x	

= 0.03767

Moment Co-efficient in longer dir. at span , α_y = 0.02400

Moment Co-efficient in longer dir. at edge , α_y = 0.03200

Factored Moment at ,

Span in shorter direction , M_{ux}
$= \alpha_x * W * L_x^2$ = 4267.18073 Nmm

Span in longer direction , M_{uy}
$= \alpha_y * W * L_x^2$ = 3599.75913 Nmm

Support in shorter direction , M'_{ux}
$= \alpha'_x * W * L_x^2$ = 5650.82128 Nmm

Support in longer direction , M'_{uy}
$= \alpha'_y * W * L_x^2$ = 4799.67883 Nmm

Width of the Slab , b = 1 mm

Limiting Moment of resistance of section

Along X-Direction , $M_{u,lim-x}$ = 24902.41494 Nmm

Along Y-Direction , $M_{u,lim-y}$ = 20407.56354 Nmm

Area Of steel reinf. in X-Dir. at span bottom , A_{stx} = 0.14400 sq. mm

Area Of steel reinf. in Y-Dir. at span bottom , A_{sty} = 0.14400 sq. mm

Area Of steel reinf. in X-Dir. at support top , A'_{stx} = 0.17115 sq. mm

Area Of steel reinf. in Y-Dir. at support top , A'_{sty} = 0.16082 sq. mm

Minimum Area Of steel reinf. in X-Dir. , $A_{stx-min}$ = 0.14400 sq. mm

Minimum Area Of steel reinf. in Y-Dir. , $A_{sty-min}$ = 0.14400 sq. mm

Cross-sectional Area Of steel in X-Dir. , $A\phi_x$
$= \pi * \phi_x^2/4$ = 78.53975 sq. mm

Cross-sectional Area Of steel in Y-Dir. , $A\phi_y$
$= \pi * \phi_y^2/4$ = 50.26544 sq. mm

Spacing in shorter Dir. at span , S_x = 280.000 mm

Spacing in longer Dir. at span , S_y = 250.000 mm

Maximum Spacing in shorter Dir. , S_{x-max} = 280.000 mm

Maximum Spacing in longer Dir. , S_{y-max} = 250.000 mm

Spacing in shorter direction at edge , S'_x = 280.000 mm

Spacing in longer direction at edge , S'_y = 250.000 mm

Calculation Of Shear

Factored shear force in shorter direction , V_{ux} = 16.06356 N

Factored shear force in longer direction , V_{uy} = 14.99150 N

Shear stress developed at shorter span , $\tau_{cx,dev}$
$= V_{ux} / (b + d_x)$ = 0.16909 MPa

Shear stress developed at longer span , $\tau_{cy,dev}$
$= V_{uy} / (b + d_y)$ = 0.17432 MPa

Percentage of steel reinf. in shorter dir. at top , P'_{tx} = 0.18015

Permissble shear stress at the section along Y-axis , τ_{cx} = 0.31169 MPa

Percentage of steel reinf. in longer dir. at top , P'_{ty} = 0.18700

Permissble shear stress at the section along X-axis , τ_{cy} = 0.31682 MPa

LOAD CONSIDERATION IN DESIGN OF G+5 BUILDING:

In this study the structure was considered for 36 load combinations. The structure designed for the worst load combinations as mentioned below

COMBINATION NO = 25 COMBINATION NO = 27 COMBINATION NO = 24 COMBINATION NO = 11

CONVENTIONAL CONCRETE DESIGN VS EARTH QUAKE RESISTANT DESIGN:

S.NO	DESCRIPTION	CONVENTIONAL CONCRETE DESIGN (m^3)	EARTHQUAKE RESISTANT DESIGN (N)	INCREASING(%)
1	Concrete	201.21	201.21	0
2	Steel	93826.84	142332.42	1.517

In earthquake resistant design the steel quantity increased by 1.517% to the conventional concrete design.

STOREY DRIFT CONDITON:

Hence the base drift = 0.0 at every storey. This says that the structure is safe under the drift condition. Hence shear – walls, Braced columns are not necessary to be provided.

Hence storey drift condition is also checked for the G+5 building.

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DESIGN SEISMIC BASE SHEAR VALIDATION:
We calculated the base shear of G+5 building both manually & by using STAAD. Pro.
à The value of base shear calculated manually as follows

Base shear,
$VB = AhW$
àThe value of base shear using STAAD. Pro presented as follows

SA/G PER 1893= 2.500, LOAD FACTOR= 1.000
FACTOR V PER 1893= 0.0400 X 15242.85 KN = 609 KN
Hence, a small difference of 23KN was observed in the base shear calculations of manually &STAAD.Pro and validated as almost equal results for earthquake resistant analysis and design of G+5 building.

Staad editor:

STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 28-Dec-17
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 3 0 0; 3 7 0 0; 4 10 0 0; 5 10 0 3; 6 10 0 7; 7 10 0 10; 8 7 0 10;
9 3 0 10; 10 0 0 10; 11 0 0 7; 12 0 0 3; 13 3 0 3; 14 3 0 7; 15 7 0 3;
16 7 0 7; 17 0 3 0; 18 3 3 0; 19 7 3 0; 20 10 3 0; 21 10 3 3; 22 10 3 7;
23 10 3 10; 24 7 3 10; 25 3 3 10; 26 0 3 10; 27 0 3 7; 28 0 3 3; 29 3 3 3;
30 3 3 7; 31 7 3 3; 32 7 3 7; 33 0 6 0; 34 3 6 0; 35 7 6 0; 36 10 6 0;
37 10 6 3; 38 10 6 7; 39 10 6 10; 40 7 6 10; 41 3 6 10; 42 0 6 10; 43 0 6 7;
44 0 6 3; 45 3 6 3; 46 3 6 7; 47 7 6 3; 48 7 6 7; 49 0 9 0; 50 3 9 0; 51 7 9 0;
52 10 9 0; 53 10 9 3; 54 10 9 7; 55 10 9 10; 56 7 9 10; 57 3 9 10; 58 0 9 10;
59 0 9 7; 60 0 9 3; 61 3 9 3; 62 3 9 7; 63 7 9 3; 64 7 9 7; 65 0 12 0;
66 3 12 0; 67 7 12 0; 68 10 12 0; 69 10 12 3; 70 10 12 7; 71 10 12 10;
72 7 12 10; 73 3 12 10; 74 0 12 10; 75 0 12 7; 76 0 12 3; 77 3 12 3; 78 3 12 7;
79 7 12 3; 80 7 12 7; 81 0 15 0; 82 3 15 0; 83 7 15 0; 84 10 15 0; 85 10 15 3;
86 10 15 7; 87 10 15 10; 88 7 15 10; 89 3 15 10; 90 0 15 10; 91 0 15 7;
92 0 15 3; 93 3 15 3; 94 3 15 7; 95 7 15 3; 96 7 15 7; 97 0 18 0; 98 3 18 0;
99 7 18 0; 100 10 18 0; 101 10 18 3; 102 10 18 7; 103 10 18 10; 104 7 18 10;
105 3 18 10; 106 0 18 10; 107 0 18 7; 108 0 18 3; 109 3 18 3; 110 3 18 7;
111 7 18 3; 112 7 18 7; 113 0 21 0; 114 3 21 0; 115 7 21 0; 116 10 21 0;
117 10 21 3; 118 10 21 7; 119 10 21 10; 120 7 21 10; 121 3 21 10; 122 0 21 10;
123 0 21 7; 124 0 21 3; 125 3 21 3; 126 3 21 7; 127 7 21 3; 128 7 21 7;
MEMBER INCIDENCES
25 1 17; 26 2 18; 27 3 19; 28 4 20; 29 5 21; 30 6 22; 31 7 23; 32 8 24;
33 9 25; 34 10 26; 35 11 27; 36 12 28; 37 13 29; 38 14 30; 39 15 31; 40 16 32;
41 17 18; 42 18 19; 43 19 20; 44 20 21; 45 21 22; 46 22 23; 47 23 24; 48 24 25;
49 25 26; 50 26 27; 51 27 28; 52 18 29; 53 29 30; 54 30 25; 55 19 31; 56 31 32;
57 32 24; 58 28 29; 59 29 31; 60 31 21; 61 27 30; 62 30 32; 63 32 22; 64 17 28;
65 17 33; 66 18 34; 67 19 35; 68 20 36; 69 21 37; 70 22 38; 71 23 39; 72 24 40;
73 25 41; 74 26 42; 75 27 43; 76 28 44; 77 29 45; 78 30 46; 79 31 47; 80 32 48;
81 33 34; 82 34 35; 83 35 36; 84 36 37; 85 37 38; 86 38 39; 87 39 40; 88 40 41;

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89 41 42; 90 42 43; 91 43 44; 92 34 45; 93 45 46; 94 46 41; 95 35 47; 96 47 48;
97 48 40; 98 44 45; 99 45 47; 100 47 37; 101 43 46; 102 46 48; 103 48 38;
104 33 44; 105 33 49; 106 34 50; 107 35 51; 108 36 52; 109 37 53; 110 38 54;
111 39 55; 112 40 56; 113 41 57; 114 42 58; 115 43 59; 116 44 60; 117 45 61;
118 46 62; 119 47 63; 120 48 64; 121 49 50; 122 50 51; 123 51 52; 124 52 53;
125 53 54; 126 54 55; 127 55 56; 128 56 57; 129 57 58; 130 58 59; 131 59 60;
132 50 61; 133 61 62; 134 62 57; 135 51 63; 136 63 64; 137 64 56; 138 60 61;
139 61 63; 140 63 53; 141 59 62; 142 62 64; 143 64 54; 144 49 60; 145 49 65;
146 50 66; 147 51 67; 148 52 68; 149 53 69; 150 54 70; 151 55 71; 152 56 72;
153 57 73; 154 58 74; 155 59 75; 156 60 76; 157 61 77; 158 62 78; 159 63 79;
160 64 80; 161 65 66; 162 66 67; 163 67 68; 164 68 69; 165 69 70; 166 70 71;
167 71 72; 168 72 73; 169 73 74; 170 74 75; 171 75 76; 172 66 77; 173 77 78;
174 78 73; 175 67 79; 176 79 80; 177 80 72; 178 76 77; 179 77 79; 180 79 69;
181 75 78; 182 78 80; 183 80 70; 184 65 76; 185 65 81; 186 66 82; 187 67 83;
188 68 84; 189 69 85; 190 70 86; 191 71 87; 192 72 88; 193 73 89; 194 74 90;
195 75 91; 196 76 92; 197 77 93; 198 78 94; 199 79 95; 200 80 96; 201 81 82;
202 82 83; 203 83 84; 204 84 85; 205 85 86; 206 86 87; 207 87 88; 208 88 89;
209 89 90; 210 90 91; 211 91 92; 212 82 93; 213 93 94; 214 94 89; 215 83 95;
216 95 96; 217 96 88; 218 92 93; 219 93 95; 220 95 85; 221 91 94; 222 94 96;
223 96 86; 224 81 92; 225 81 97; 226 82 98; 227 83 99; 228 84 100; 229 85 101;
230 86 102; 231 87 103; 232 88 104; 233 89 105; 234 90 106; 235 91 107;
236 92 108; 237 93 109; 238 94 110; 239 95 111; 240 96 112; 241 97 98;
242 98 99; 243 99 100; 244 100 101; 245 101 102; 246 102 103; 247 103 104;
248 104 105; 249 105 106; 250 106 107; 251 107 108; 252 98 109; 253 109 110;
254 110 105; 255 99 111; 256 111 112; 257 112 104; 258 108 109; 259 109 111;
260 111 101; 261 107 110; 262 110 112; 263 112 102; 264 97 108; 265 97 113;
266 98 114; 267 99 115; 268 100 116; 269 101 117; 270 102 118; 271 103 119;
272 104 120; 273 105 121; 274 106 122; 275 107 123; 276 108 124; 277 109 125;
278 110 126; 279 111 127; 280 112 128; 281 113 114; 282 114 115; 283 115 116;
284 116 117; 285 117 118; 286 118 119; 287 119 120; 288 120 121; 289 121 122;
290 122 123; 291 123 124; 292 114 125; 293 125 126; 294 126 121; 295 115 127;
296 127 128; 297 128 120; 298 124 125; 299 125 127; 300 127 117; 301 123 126;
302 126 128; 303 128 118; 304 113 124;
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 27579
END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
41 TO 64 81 TO 104 121 TO 144 161 TO 184 201 TO 224 241 TO 264 281 TO 303 -
304 PRIS YD 0.7 ZD 0.6
25 TO 40 65 TO 80 105 TO 120 145 TO 160 185 TO 200 225 TO 240 265 TO 279 -
280 PRIS YD 0.6 ZD 0.6
CONSTANTS
```

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MATERIAL CONCRETE ALL
SUPPORTS
1 TO 16 FIXED
DEFINE 1893 LOAD
ZONE 0.36 RF 5 I 1 SS 2 ST 1 DM 0.05 PX 0.68 PZ 0.68 DT 5
SELFWEIGHT 1
FLOOR WEIGHT
YRANGE 3 24 FLOAD 3.75
YRANGE 3 21 FLOAD 2
MEMBER WEIGHT
25 TO 280 UNI 19.5
52 TO 63 92 TO 103 132 TO 143 172 TO 183 212 TO 223 252 TO 263 292 TO 302 -
303 UNI 11.8
281 TO 291 304 UNI 8
LOAD 1 LOADTYPE Seismic  TITLE EQX
1893 LOAD X 1
LOAD 2 LOADTYPE Seismic  TITLE EQZ
1893 LOAD Z 1
LOAD 3 LOADTYPE Dead  TITLE DEAD LOAD
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 3 24 FLOAD -3.75 GY
MEMBER LOAD
25 TO 280 UNI GY -19.15
52 TO 63 92 TO 103 132 TO 143 172 TO 183 212 TO 223 252 TO 263 292 TO 302 -
303 UNI GY -11.8
281 TO 291 304 UNI GY -8
LOAD 4 LOADTYPE Roof Live REDUCIBLE TITLE RLL
FLOOR LOAD
YRANGE 22 24 FLOAD -2 GY
LOAD 6 LOADTYPE Live  TITLE LIVE LOAD
FLOOR LOAD
YRANGE 3 21 FLOAD -4 GY
***********
***********
**LOAD COMBINATIONS FOR FRAME DESIGN
****
**LOAD COMB 5 1.5(DL+LL)
**3 1.5 6 1.5
**LOAD COMB 7 1.2(DL+LL+EQX)
**1 1.2 3 1.2 6 1.2
**LOAD COMB 8 1.2(DL+LL-EQX)
**1 1.2 3 1.2 6 -1.2
**LOAD COMB 9 1.2(DL+LL+EQZ)
**2 1.2 3 1.2 6 1.2
**LOAD COMB 10 1.2(DL+LL-EQZ)
**2 1.2 3 1.2 6 -1.2
**LOAD COMB 11 1.5(DL+EQX)
**1 1.5 3 1.5
```

```
**LOAD COMB 12 1.5(DL-EQX)
**1 1.5 3 -1.5
**LOAD COMB 13 1.5(DL+EQZ)
**2 1.5 3 1.5
**LOAD COMB 14 1.5(DL-EQZ)
**2 1.5 3 -1.5
**************
**************
**LOAD COMBINATION FOR FOUNDATION DESIGN
**
LOAD COMB 15 DL+LL
3 1.0 6 1.0
LOAD COMB 16 DL+0.5LL+EQX
1 1.0 3 1.0 6 1.0
LOAD COMB 17 DL+0.5LL-EQX
1 1.0 3 1.0 6 -1.0
LOAD COMB 18 DL+0.5LL+EQZ
2 1.0 3 1.0 6 1.0
LOAD COMB 19 DL+0.5LL-EQZ
2 1.0 3 1.0 6 -1.0
LOAD COMB 20 DL+EQX
1 1.0 3 1.0
LOAD COMB 21 DL-EQX
1 1.0 3 -1.0
LOAD COMB 22 DL+EQZ
2 1.0 3 1.0
LOAD COMB 23 DL-EQZ
2 1.0 3 -1.0
PERFORM ANALYSIS
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS
PERFORM ANALYSIS
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS
PERFORM ANALYSIS
START CONCRETE DESIGN
CODE INDIAN
CLEAR 0.025 MEMB 41 TO 64 81 TO 104 121 TO 144 161 TO 184 201 TO 224 -
241 TO 264 281 TO 304
CLEAR 0.04 MEMB 25 TO 40 65 TO 80 105 TO 120 145 TO 160 185 TO 200 -
225 TO 240 265 TO 280
FC 30000 ALL
FYMAIN 415000 ALL
FYSEC 415000 ALL
MAXMAIN 25 ALL
MAXSEC 16 ALL
RATIO 4 MEMB 25 TO 40 65 TO 80 105 TO 120 145 TO 160 185 TO 200 225 TO 240 -
```

265 TO 280
DESIGN BEAM 41 TO 64 81 TO 104 121 TO 144 161 TO 184 201 TO 224 241 TO 264 -
281 TO 304
DESIGN COLUMN 25 TO 40 65 TO 80 105 TO 120 145 TO 160 185 TO 200 225 TO 240 -
265 TO 280
CONCRETE TAKE
END CONCRETE DESIGN
PERFORM ANALYSIS
PERFORM ANALYSIS
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS
PERFORM ANALYSIS
FINISH

Conclusion

- STAAD PRO has the capability to calculate the reinforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS: 456(2000). Beams are designed for flexure, shear and torsion.
- Design for Flexure:
- Maximum sagging (creating tensile stress at the bottom face of the beam) and hogging (creating tensile stress at the top face) moments are calculated for all active load cases at each of the above mentioned sections. Each of these sections are designed to resist both of these critical sagging and hogging moments. Where ever the rectangular section is inadequate as singly reinforced section, doubly reinforced section is tried.
- Design for Shear:
- Shear reinforcement is calculated to resist both shear forces and torsional moments. Shear capacity calculation at different sections without the shear reinforcement is based on the actual tensile reinforcement provided by STAAD program. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections.
- Beam Design Output:
- The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.
- Column Design:
- Columns are designed for axial forces and biaxial moments at the ends. All active load cases are tested to calculate reinforcement. The loading which yield maximum reinforcement is called the critical load. Column design is done for square section. Square columns are designed with reinforcement distributed on each side equally for the sections under biaxial moments and with reinforcement distributed equally in two faces for sections under uni-axial moment. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of STAAD.

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