ANALYSIS AND CAPACITY BASED EARTHQUAKE RESISTANT DESIGN OF MULTIBAY MULTI STOREYED RC FRAME.

A PROJECT SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Civil Engineering

By

M.VASAVI

Department of Civil Engineering

National Institute of Technology, Rourkela

May, 2007

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Under the Guidance of

Prof. ASHA PATEL

Department of Civil Engineering

National Institute of Technology

Rourkela

2007

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CERTIFICATE

This is to certify that the thesis entitled, "Analysis & Capacity Based Earthquake Resistant Design Of Multi Bay Multi Storeyed RC Frame" submitted by Ms. M.Vasavi in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Civil Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by her under my supervision and guidance .

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date : 03/05/2007 Professor Asha Patel

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Date: May 3, 2007 M.Vasavi

CONTENTS

ABSTRACT

Earthquakes in different parts of the world demonstrated the disastrous consequences and vulnerability of inadequate structures. Many reinforced concrete (RC) framed structures located in zones of high seismicity in India are constructed without considering the seismic codal provisions. The vulnerability of inadequately designed structures represents seismic risk to occupants.

The main cause of failure of multi-storey multi-bay reinforced concrete frames during seismic motion is the soft storey sway mechanism or column sway mechanism. If the frame is designed on the basis of strong column-weak beam concept the possibilities of collapse due to sway mechanisms can be completely eliminated. In multi storey frame this can be achieved by allowing the plastic hinges to form, in a predetermined sequences only at the ends of all the beams while the columns remain essentially in elastic stage and by avoiding shear mode of failures in columns and beams. This procedure for design is known as Capacity based design which would be the future design philosophy for earthquake resistant design of multi storey multi bay reinforced concrete frames.

The aim of this project work is to present a detailed worked out example on seismic analysis and capacity based design of four-storey reinforced concrete frame building.

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Chapter 1

INTRODUCTION

INTRODUCTION

Civil engineering structures are mainly designed to resist static loads. Generally the effects of dynamic loads acting on the structure are not considered. This feature of neglecting the dynamic forces sometimes becomes the cause of disaster, particularly in case of earthquake. The resent example of this category is Bhuj earthquake occurred on Jan.26, 2001. This has created a growing interest and need for earthquake resistant design of structures.

Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. The strength is related to ultimate limit state, which assures that the forces developed in the structure remain in elastic range. The stiffness is related to serviceability limit state which assures that the structural displacements remains within the permissible limits. In case of earthquake forces the demand is for ductility. Ductility is an essential attribute of a structure that must respond to strong ground motions. Ductility is the ability of the structure to undergo distortion or deformation without damage or failure which results in dissipation of energy. Larger is the capacity of the structure to deform plastically without collapse, more is the resulting ductility and the energy dissipation. This causes reduction in effective earthquake forces. Hence based on the three criteria strength, stiffness and ductility the methods for seismic design are described below:

LATERAL STRENGTH BASED DESIGN:

This is most common seismic design approach adopted nowadays. It is based on providing the structure with the minimum lateral strength to resist seismic loads, assuming that the structure will behave adequately in the non-linear range. For this reason only some simple construction detail rules are needed to be satisfied.

DISPLACEMENT BASED DESIGN:

In this method the structure is designed to possess adequate ductility so that it can dissipate energy by yielding and survive the shock. This method operates directly with deformation quantities hence gives better insight on the expected performance of the structures. The displacement based design approach has been adopted by the seismic codes of many countries.

CAPACITY BASED DESIGN:

In this design approach the structures are designed in such a way so that plastic hinges can form only in predetermined positions and in predetermined sequences. The concept of this method is to avoid brittle mode of failure. This is achieved by designing the brittle modes of failure to have higher strength than ductile modes.

ENERGY BASED DESIGN:

This is the most promising and futuristic approach of earthquake resistant design. In this approach it is assume that the total energy input is collectively resisted by kinetic energy, the elastic strain energy and energy dissipated through plastic deformations and damping.

Chapter 2

Seismic Analysis Procedures

Seismic Analysis Procedure

Procedure for Seismic analysis:

Equivalent lateral force method:

The Equivalent lateral force method is the simplest method of analysis and requires less computational effort because the forces depend on the code based fundamental period of structures with some empirical modifier. The design base shear shall first be computed as a whole, and then be distributed along the height of buildings based on simple formulae appropriate for buildings with regular distribution of mass and stiffness. The design lateral force obtained at each floor level shall be distributed to individual lateral load resisting elements depending upon floor diaphragm action.

The design lateral force or design base shear and the distribution are given by some empirical formulae given in the I.S 1893.

Response Spectrum analysis:

This method is applicable for those structures where modes other than the fundamental one affect significantly the response of the structure. In this method the response of Multi degree of freedom system is expressed as the superposition of modal response,each modal response being determined from the spectral analysis of Single–degree of freedom system ,which are then combined to compute the total response.

Elastic Time history analysis:

A linear analysis, time history analysis over comes all disadvantages of modal response spectrum provided non linear behaviour is not involved. The method requires greater computational efforts for calculating the response at discrete times. One interesting advantage of this is that the relative signs of response quantities are preserved in the response histories.

The analysis of an R.C frame for calculating the base shear and its distribution over each floor is done by using the Equivalent Lateral force method. The program below is done for finding the values:

```
#include<iostream.h>
#include<math.h>
void main()
{
int n,H;
float z,w,D,d;
cout<<"enter the height of the building"<<endl;
cin>>H;
cout<<"enter the no. of floors"<<endl;
cin>>n;
cout<<"enter the total load acting "<<endl;
cin>>w;
cout<<"enter the zone factor"<<endl;
cin>>z;
float i;int x;
cout<<"enter the purpose of the structure"<<endl;
cout<<"1:important service and community building"<<endl;
cout<<"2:others"<<endl;
cin>>x;
switch(x)
{
case 1:{i=1.5; cout<<"i=1.5"<<endl; break;}
case 2:{ i=1.0;cout<<"i=1.0"<<endl; break;}
default:cout<<"input error ,check again"<<endl;
}
```

```
float t,a;int r,y;
a=pow(H,0.75);d=pow(D,0.5);
cout<<"enter the type of lateral loading system"<<endl;
cout<<"3:ordinary RC moment resisting frame"<<endl;
cout<<"4:special RC moment resisting frame"<<endl;
cout<<"5:steel frame with concrete base"<<endl;
cout<<"6:steel frame with eccentric base"<<endl;
cout<<"7:moment resisting frame with brick infil"<<endl;
cin>>y;
switch(y)
{
case 3: {r=3;t=0.075*a;cout<<"r=3";break;}
case 4:{ r=5;t=0.075*a;cout<<"r=5"; break; }
case 5: { r=4;t=0.085*a;cout<<"r=4"; break;  }
case 6:{ r=5;t=0.085*a;cout<<"r=5"; break; }
case 7:{ r=5;t=0.09*(H/d);cout<<"r=5";break;}
default: cout<<"error in input,check again"<<endl;
}
cout<<"r="<<r<<endl;
cout<<"t="<<t<<endl;float s;
if(t>0&&t<=0.1)
s=1+(15*t);
else
  { if(t>0.1&&t<=0.4)
    s=2.50;
    else{
    if(t>0.4&&t<=4.0)
    s=1/t;
    else cout<<"t>4 not defined"<<endl; }
   }
cout<<"s="<<s;
```

```
float A,V;
A=(0.5*z*i*s)/r;
V=w*A;
cout<<"A="<<A<<"  "<<"V="<<V<<endl;
int m,l[20];float S,W[20],b[20],Q[20];
S=0;
for(m=1;m<=n;m++)
{
cout<<"enter the ht. of floor "<<m<<" from base and the lumped mass"<<endl;
cin>>l[m];
cin>>W[m];
b[m]=pow(l[m],2);
S=(W[m]*b[m])+S;}
for(m=1;m<=n;m++)
{
Q[m]=(V*W[m]*b[m])/S;
cout<<"Q"<<m<<"="<<Q[m]<<endl;  } }
```

Chapter 3

Capacity based design

CAPACITY BASED DESIGN

The basic concept of capacity based design of structures is the spreading of inelastic deformation demands in a structure in such a way so that the formation of plastic hinges takes place at predetermined positions and sequences.

In multistory multi bay reinforced concrete frames plastic hinges are allowed to form only at the ends of the beams .To achieve this flexural capacity of column sections at each joint are made more than the joining beam sections. This will eliminate the possible sway mechanism of the frame.

The capacity design is also the art of avoiding failure of structure in brittle mode . This can be achieved by designing the brittle modes of failure to have higher strength than ductile modes. Shear failure is brittle mode of failure hence shear capacity of all components are made higher than their flexural capacities.

Step by step procedure for capacity based design

1. Design loads i.e. dead loads, live loads and earthquake loads are calculated.
2. Seismic analysis of the frame for all load combination specified in IS 1893(Part I):2002 are done.
3. Members are designed (as per IS 456:200) for maximum forces obtained from all load combinations.

   Beams are designed for maximum sagging and maximum hogging moments.

   Provided reinforcements are calculated following the norms given in code.

   Columns are designed for the combination for moment and corresponding axial force providing maximum interaction effect i.e. considering the eccentricity.
4. The flexural capacities of the beams under sagging and hogging condition for the provided reinforcements are calculated.

5. The flexural capacity of columns at a joint is compared with actual flexural capacity of joining beams.

   If the sum of capacities of columns is less than the sum of capacities of beams multiplied by over strength factor, the column moments should be magnified by the factor (moment magnification factor) by which they are lacking in moment capacity over beams.

   If the sum of the column moments is greater than sum of beam moments, there is no need to magnify the column moments.
6. Columns are designed for the revised moments and the axial force coming on it from the analysis.
7. Shear capacity of beams are calculated on the basis or their actual moment capacities and shear reinforcements are calculated.
8. Similarly shear capacity of column is calculated on the basis of magnified moment capacities. Then the columns are designed for shear.

Chapter 4

Analysis and Design of RC frame

Analysis and Design of RC frame

Problem Statement:

Floor plan of a public cum office building is given. The plan is regular and has all columns equally placed. The building space frame is divided into a number of frames. An interior frame 4-4 is considered for the analysis and design. The salient features of the frame are:

1. Type of structure --- multi storey rigid joint frame.
2. seismic zone --- 4
3. No. of stories --- 4 (G+3)
4. ground storey ht --- 4.0 m
5. floor to floor ht --- 3.35 m
6. external walls --- 250mm thick
7. internal walls --- 150mm thick
8. Live Load --- 3.5 kN/m^2
9. Materials --- M 20 and Fe 415
10. Seismic analysis --- Equivalent Static method
11. Size of columns---- 300x530mm
12. Size of the beams ----- 300x450mm
13. Total slab depth ---- 120mm

Loading Data:

Dead Load:

Terrace water proofing = 1.5 kN/m^2

Floor finish = 0.5 kN/m^2

Live Load:

Roof = 1.5 kN/m^2

Live load on Floor = 3.5 kN/m^2

Analysis

The dead load and the imposed loads have been calculated for the floors and the roof.

The calculated values are as follows:

For the external beams:

Total dead load on the roof = 13.684 kN/m

Total dead load on the floors = 24.86 kN/m

Total imposed load on the roof =3.32 kN/m

Total imposed load on the floors= 7.74 kN/m

For the internal beams:

Total dead load on the roof =8.375 kN/m

Total dead load on the floors= 21.15 kN/m

Total imposed load on the roof = 1.75 kN/m

Total imposed load on the floors= 4.00 kN/m

The input data for seismic analysis:

Zone = 4 , Zone factor =0.24

Height of the building = 14.05m

No. of floors = 4

Importance factor = 1

R=5 (special RC moment resisting frame)

The weight of each floor:

First floor = 6622kN

Second floor = 6578kN

Third floor = 6578kN

Roof level = 5074kN

The values of the base shear are :

First floor Q=6.00 kN

Second floor Q=20.00kN

Third floor Q=42.50kN

Roof level Q=56.50kN

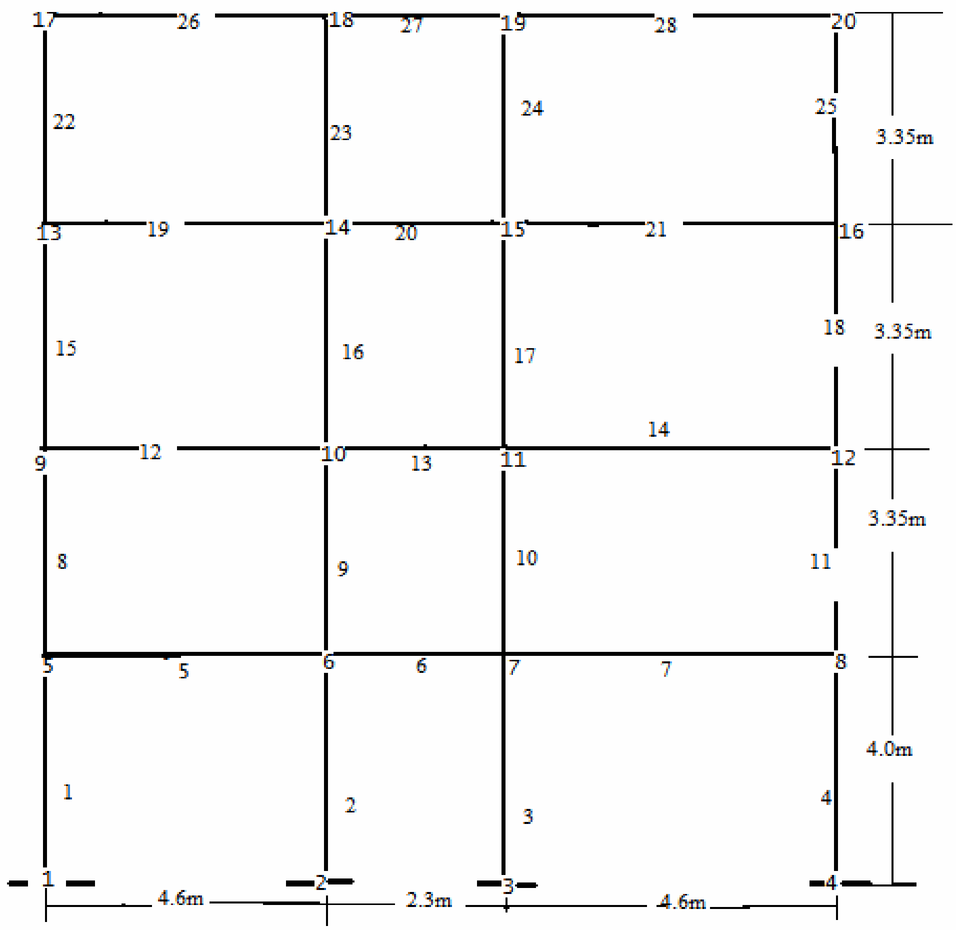

Fig:4.1 RC Frame : Dimensions and numbering

Using the above data, analysis of the frame is carried out with all the load combinations as per IS 1893(Part 1):2002. The maximum moments and forces for the beams and columns for all the load combinations for each member is considered for the design.

The different load combinations are:

1. 1.5(DL+IL)
2. 1.2(DL+IL+EL)
3. 1.2(DL+IL-EL)
4. 1.5(DL+EL)
5. 1.5(DL-EL)
6. 0.9DL+1.5EL
7. 0.9DL-1.5EL

The analysis of the frame is done by STAAD PRO-2004. The results are as follows and the maximum values in all combinations are considered:

Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
1	5 CASE1	1	421.606	-12.993	0	0	0	-17.224
		5	-421.606	12.993	0	0	0	-34.747
	6 CASE2	1	224.9	43.067	0	0	0	143.069
		5	-224.9	-43.067	0	0	0	29.198
	7 CASE3	1	449.254	-63.82	0	0	0	-170.438
		5	-449.254	63.82	0	0	0	-84.843
	8 CASE4	1	183.769	56.915	0	0	0	182.92
		5	-183.769	-56.915	0	0	0	44.741
	9 CASE5	1	464.21	-76.694	0	0	0	-208.964
		5	-464.21	76.694	0	0	0	-97.811
	10 CASE6	1	54.069	60.879	0	0	0	188.176
		5	-54.069	-60.879	0	0	0	55.342
	11 CASE7	1	334.51	-72.729	0	0	0	-203.708
		5	-334.51	72.729	0	0	0	-87.209
2	5 CASE1	2	518.158	3.081	0	0	0	4.067
		6	-518.158	-3.081	0	0	0	8.256
	6 CASE2	2	409.868	24.026	0	0	0	47.642
		6	-409.868	-24.026	0	0	0	48.46
	7 CASE3	2	419.601	-19.087	0	0	0	-41.118
		6	-419.601	19.087	0	0	0	-35.231
	8 CASE4	2	402.847	29.23	0	0	0	58.493
		6	-402.847	-29.23	0	0	0	58.425
	9 CASE5	2	415.013	-24.661	0	0	0	-52.457

		6	-415.013	24.661	0	0	0	-46.189
	10 CASE6	2	239.379	28.318	0	0	0	57.29
		6	-239.379	-28.318	0	0	0	55.983
	11 CASE7	2	251.545	-25.573	0	0	0	-53.66
		6	-251.545	25.573	0	0	0	-48.632
3	5 CASE1	3	518.159	-3.081	0	0	0	-4.067
		7	-518.159	3.081	0	0	0	-8.256
	6 CASE2	3	419.601	19.087	0	0	0	41.118
		7	-419.601	-19.087	0	0	0	35.231
	7 CASE3	3	409.868	-24.026	0	0	0	-47.642
		7	-409.868	24.026	0	0	0	-48.46
	8 CASE4	3	415.013	24.661	0	0	0	52.457
		7	-415.013	-24.661	0	0	0	46.189
	9 CASE5	3	402.847	-29.23	0	0	0	-58.493
		7	-402.847	29.23	0	0	0	-58.425
	10 CASE6	3	251.545	25.573	0	0	0	53.66
		7	-251.545	-25.573	0	0	0	48.632
	11 CASE7	3	239.379	-28.318	0	0	0	-57.29
		7	-239.379	28.318	0	0	0	-55.983

4	5 CASE1	4	421.606	12.993	0	0	0	17.224
		8	-421.606	-12.993	0	0	0	34.747
	6 CASE2	4	449.254	63.82	0	0	0	170.438
		8	-449.254	-63.82	0	0	0	84.843
	7 CASE3	4	224.9	-43.067	0	0	0	-143.069

		8	-224.9	43.067	0	0	0	-29.198
	8 CASE4	4	464.21	76.694	0	0	0	208.964
		8	-464.21	-76.694	0	0	0	97.811
	9 CASE5	4	183.769	-56.915	0	0	0	-182.92
		8	-183.769	56.915	0	0	0	-44.741
	10 CASE6	4	334.51	72.729	0	0	0	203.708
		8	-334.51	-72.729	0	0	0	87.209
	11 CASE7	4	54.069	-60.879	0	0	0	-188.176
		8	-54.069	60.879	0	0	0	-55.342
5	5 CASE1	5	-17.065	117.755	0	0	0	87.572
		6	17.065	107.185	0	0	0	-63.262
	6 CASE2	5	-24.965	56.426	0	0	0	-39.687
		6	24.965	123.526	0	0	0	-114.642
	7 CASE3	5	4.904	131.912	0	0	0	179.576
		6	-4.904	48.04	0	0	0	13.33
	8 CASE4	5	-27.209	42.542	0	0	0	-70.336
		6	27.209	128.992	0	0	0	-128.499
	9 CASE5	5	10.128	136.899	0	0	0	203.742
		6	-10.128	34.635	0	0	0	31.465
	10 CASE6	5	-21.982	6.636	0	0	0	-97.074
		6	21.982	96.284	0	0	0	-109.116
	11 CASE7	5	15.355	100.993	0	0	0	177.005
		6	-15.355	1.927	0	0	0	50.849
6	5 CASE1	6	-12.201	43.384	0	0	0	41.217
		7	12.201	43.384	0	0	0	-41.217
	6 CASE2	6	-6.125	0.485	0	0	0	-6.376
		7	6.125	68.929	0	0	0	-72.335
	7 CASE3	6	-6.125	68.929	0	0	0	72.335
		7	6.125	0.485	0	0	0	6.376
	8 CASE4	6	-4.942	-6.294	0	0	0	-17.015
		7	4.942	79.261	0	0	0	-81.374
	9 CASE5	6	-4.942	79.261	0	0	0	81.374

		7	4.942	-6.294	0	0	0	17.015
	10 CASE6	6	-1.147	-20.887	0	0	0	-29.884
		7	1.147	64.668	0	0	0	-68.505
	11 CASE7	6	-1.147	64.668	0	0	0	68.505
		7	1.147	-20.887	0	0	0	29.884

7	5 CASE1	7	-17.065	107.185	0	0	0	63.262
		8	17.065	117.755	0	0	0	-87.572
	6 CASE2	7	4.904	48.04	0	0	0	-13.329
		8	-4.904	131.912	0	0	0	-179.576
	7 CASE3	7	-24.965	123.526	0	0	0	114.642
		8	24.965	56.426	0	0	0	39.687
	8 CASE4	7	10.128	34.635	0	0	0	-31.465
		8	-10.128	136.899	0	0	0	-203.742
	9 CASE5	7	-27.209	128.992	0	0	0	128.499
		8	27.209	42.542	0	0	0	70.336
	10 CASE6	7	15.355	1.927	0	0	0	-50.849
		8	-15.355	100.993	0	0	0	-177.005
	11 CASE7	7	-21.982	96.284	0	0	0	109.116
		8	21.982	6.636	0	0	0	97.074
8	5 CASE1	5	303.851	-30.057	0	0	0	-52.825
		9	-303.851	30.057	0	0	0	-47.867
	6 CASE2	5	168.474	10.901	0	0	0	10.489
		9	-168.474	-10.901	0	0	0	26.031
	7 CASE3	5	317.342	-58.916	0	0	0	-94.733
		9	-317.342	58.916	0	0	0	-102.636
	8 CASE4	5	141.227	20.706	0	0	0	25.595
		9	-	-20.706	0	0	0	43.771

			141.227					
	9 CASE5	5	327.311	-66.566	0	0	0	-105.932
		9	-327.311	66.566	0	0	0	-117.063
	10 CASE6	5	47.433	29.897	0	0	0	41.732
		9	-47.433	-29.897	0	0	0	58.425
	11 CASE7	5	233.517	-57.374	0	0	0	-89.795
		9	-233.517	57.374	0	0	0	-102.409
9	5 CASE1	6	367.589	7.945	0	0	0	13.789
		10	-367.589	-7.945	0	0	0	12.827
	6 CASE2	6	285.858	42.866	0	0	0	72.557
		10	-285.858	-42.866	0	0	0	71.044
	7 CASE3	6	302.632	-30.116	0	0	0	-50.433
		10	-302.632	30.116	0	0	0	-50.457
	8 CASE4	6	280.149	51.497	0	0	0	87.088
		10	-280.149	-51.497	0	0	0	85.427
	9 CASE5	6	301.117	-39.731	0	0	0	-66.649
		10	-301.117	39.731	0	0	0	-66.45
	10 CASE6	6	163.983	49.153	0	0	0	83.016
		10	-163.983	-49.153	0	0	0	81.648
	11 CASE7	6	184.95	-42.075	0	0	0	-70.722
		10	-184.95	42.075	0	0	0	-70.229
10	5 CASE1	7	367.589	-7.945	0	0	0	-13.789
		11	-367.589	7.945	0	0	0	-12.827
	6 CASE2	7	302.632	30.116	0	0	0	50.433
		11	-302.632	-30.116	0	0	0	50.457
	7 CASE3	7	285.858	-42.866	0	0	0	-72.557
		11	-285.858	42.866	0	0	0	-71.044
	8 CASE4	7	301.117	39.731	0	0	0	66.649

		11	-301.117	-39.731	0	0	0	66.45
	9 CASE5	7	280.149	-51.497	0	0	0	-87.088
		11	-280.149	51.497	0	0	0	-85.427
	10 CASE6	7	184.95	42.075	0	0	0	70.722
		11	-184.95	-42.075	0	0	0	70.229
	11 CASE7	7	163.983	-49.153	0	0	0	-83.016
		11	-163.983	49.153	0	0	0	-81.648
11	5 CASE1	8	303.851	30.057	0	0	0	52.825
		12	-303.851	-30.057	0	0	0	47.867
	6 CASE2	8	317.342	58.916	0	0	0	94.733
		12	-317.342	-58.916	0	0	0	102.636
	7 CASE3	8	168.474	-10.901	0	0	0	-10.489
		12	-168.474	10.901	0	0	0	-26.031
	8 CASE4	8	327.311	66.566	0	0	0	105.932
		12	-327.311	-66.566	0	0	0	117.063
	9 CASE5	8	141.227	-20.706	0	0	0	-25.595
		12	-141.227	20.706	0	0	0	-43.771
	10 CASE6	8	233.517	57.374	0	0	0	89.795
		12	-233.517	-57.374	0	0	0	102.409
	11 CASE7	8	47.433	-29.897	0	0	0	-41.732
		12	-47.433	29.897	0	0	0	-58.425
12	5 CASE1	9	1.96	119.648	0	0	0	94.214
		10	-1.96	105.292	0	0	0	-61.196
	6 CASE2	9	20.754	60.406	0	0	0	-25.21
		10	-20.754	119.546	0	0	0	-110.811
	7 CASE3	9	6.594	130.889	0	0	0	175.49
		10	-6.594	49.063	0	0	0	12.708
	8 CASE4	9	25.563	47.134	0	0	0	-53.681
		10	-25.563	124.4	0	0	0	-

								124.029
	9 CASE5	9	7.862	135.238	0	0	0	197.195
		10	-7.862	36.296	0	0	0	30.37
	10 CASE6	9	24.931	10.625	0	0	0	-82.499
		10	-24.931	92.296	0	0	0	-105.345
	11 CASE7	9	7.23	98.728	0	0	0	168.376
		10	-7.23	4.193	0	0	0	49.054
13	5 CASE1	10	1.123	43.384	0	0	0	36.485
		11	-1.123	43.384	0	0	0	-36.485
	6 CASE2	10	13.014	-6.882	0	0	0	-18.625
		11	-13.014	76.296	0	0	0	-77.029
	7 CASE3	10	13.014	76.296	0	0	0	77.029
		11	-13.014	-6.882	0	0	0	18.625
	8 CASE4	10	16.055	-15.502	0	0	0	-31.197
		11	-16.055	88.47	0	0	0	-88.37
	9 CASE5	10	16.055	88.47	0	0	0	88.37
		11	-16.055	-15.502	0	0	0	31.197
	10 CASE6	10	15.691	-30.096	0	0	0	-42.625
		11	-15.691	73.876	0	0	0	-76.943
	11 CASE7	10	15.691	73.876	0	0	0	76.943
		11	-15.691	-30.096	0	0	0	42.625
14	5 CASE1	11	1.96	105.292	0	0	0	61.196
		12	-1.96	119.648	0	0	0	-94.214
	6 CASE2	11	6.594	49.063	0	0	0	-12.708
		12	-6.594	130.889	0	0	0	-175.49
	7 CASE3	11	20.754	119.546	0	0	0	110.811
		12	-20.754	60.406	0	0	0	25.21
	8 CASE4	11	7.862	36.296	0	0	0	-30.37
		12	-7.862	135.238	0	0	0	-197.195
	9 CASE5	11	25.563	124.4	0	0	0	124.029
		12	-25.563	47.134	0	0	0	53.681
	10 CASE6	11	7.23	4.193	0	0	0	-49.054
		12	-7.23	98.728	0	0	0	-168.376

	11 CASE7	11	24.931	92.296	0	0	0	105.345
		12	-24.931	10.625	0	0	0	82.499
15	5 CASE1	9	184.203	-28.097	0	0	0	-46.347
		13	-184.203	28.097	0	0	0	-47.779
	6 CASE2	9	108.068	7.655	0	0	0	-0.821
		13	-108.068	-7.655	0	0	0	26.466
	7 CASE3	9	186.453	-52.323	0	0	0	-72.854
		13	-186.453	52.323	0	0	0	-102.426
	8 CASE4	9	94.092	16.269	0	0	0	9.91
		13	-94.092	-16.269	0	0	0	44.591
	9 CASE5	9	192.074	-58.703	0	0	0	-80.132
		13	-192.074	58.703	0	0	0	-116.525
	10 CASE6	9	36.808	24.828	0	0	0	24.075
		13	-36.808	-24.828	0	0	0	59.099
	11 CASE7	9	134.789	-50.144	0	0	0	-65.967
		13	-134.789	50.144	0	0	0	-102.017
16	5 CASE1	10	218.914	7.108	0	0	0	11.885
		14	-218.914	-7.108	0	0	0	11.927
	6 CASE2	10	173.194	35.126	0	0	0	58.392
		14	-173.194	-35.126	0	0	0	59.28
	7 CASE3	10	177.273	-23.696	0	0	0	-39.28
		14	-177.273	23.696	0	0	0	-40.101
	8 CASE4	10	171.252	41.989	0	0	0	69.799
		14	-171.252	-41.989	0	0	0	70.864
	9 CASE5	10	176.351	-31.538	0	0	0	-52.291
		14	-176.351	31.538	0	0	0	-53.363
	10 CASE6	10	101.782	39.913	0	0	0	66.322
		14	-101.782	-39.913	0	0	0	67.388

	11 CASE7	10	106.881	-33.614	0	0	0	-55.768
		14	-106.881	33.614	0	0	0	-56.839
17	5 CASE1	11	218.914	-7.108	0	0	0	-11.885
		15	-218.914	7.108	0	0	0	-11.927
	6 CASE2	11	177.273	23.696	0	0	0	39.28
		15	-177.273	-23.696	0	0	0	40.101
	7 CASE3	11	173.194	-35.126	0	0	0	-58.392
		15	-173.194	35.126	0	0	0	-59.28
	8 CASE4	11	176.351	31.538	0	0	0	52.291
		15	-176.351	-31.538	0	0	0	53.363
	9 CASE5	11	171.252	-41.989	0	0	0	-69.799
		15	-171.252	41.989	0	0	0	-70.864
	10 CASE6	11	106.881	33.614	0	0	0	55.768
		15	-106.881	-33.614	0	0	0	56.839
	11 CASE7	11	101.782	-39.913	0	0	0	-66.322
		15	-101.782	39.913	0	0	0	-67.388
18	5 CASE1	12	184.204	28.097	0	0	0	46.347
		16	-184.204	-28.097	0	0	0	47.779
	6 CASE2	12	186.453	52.323	0	0	0	72.854
		16	-186.453	-52.323	0	0	0	102.426
	7 CASE3	12	108.068	-7.655	0	0	0	0.821
		16	-108.068	7.655	0	0	0	-26.466
	8 CASE4	12	192.074	58.703	0	0	0	80.132
		16	-192.074	-58.703	0	0	0	116.525
	9 CASE5	12	94.092	-16.269	0	0	0	-9.91
		16	-94.092	16.269	0	0	0	-44.591
	10	12	134.789	50.144	0	0	0	65.967

	CASE6							
		16	-134.789	-50.144	0	0	0	102.017
	11 CASE7	12	36.808	-24.828	0	0	0	-24.075
		16	-36.808	24.828	0	0	0	-59.099
19	5 CASE1	13	-1.028	120.476	0	0	0	95.749
		14	1.028	104.464	0	0	0	-58.92
	6 CASE2	13	34.686	70.664	0	0	0	3.372
		14	-34.686	109.288	0	0	0	-92.209
	7 CASE3	13	14.438	121.96	0	0	0	149.373
		14	-14.438	57.992	0	0	0	-2.247
	8 CASE4	13	42.828	59.823	0	0	0	-18.076
		14	-42.828	111.711	0	0	0	-101.266
	9 CASE5	13	17.518	123.943	0	0	0	164.425
		14	-17.518	47.591	0	0	0	11.187
	10 CASE6	13	43.451	23.035	0	0	0	-47.459
		14	-43.451	79.885	0	0	0	-83.296
	11 CASE7	13	18.141	87.155	0	0	0	135.042
		14	-18.141	15.765	0	0	0	29.157
20	5 CASE1	14	-2.529	43.384	0	0	0	36.693
		15	2.529	43.384	0	0	0	-36.693
	6 CASE2	14	23.351	3.346	0	0	0	-6.699
		15	-23.351	66.068	0	0	0	-65.432
	7 CASE3	14	23.351	66.068	0	0	0	65.432
		15	-23.351	3.346	0	0	0	6.699
	8 CASE4	14	29.222	-2.718	0	0	0	-16.513
		15	-29.222	75.685	0	0	0	-73.651
	9 CASE5	14	29.222	75.685	0	0	0	73.651
		15	-29.222	-2.718	0	0	0	16.513
	10 CASE6	14	30.221	-17.311	0	0	0	-27.935
		15	-30.221	61.092	0	0	0	-62.229
	11 CASE7	14	30.221	61.092	0	0	0	62.229
		15	-30.221	-17.311	0	0	0	27.935
21	5 CASE1	15	-1.028	104.464	0	0	0	58.92

		16	1.028	120.476	0	0	0	-95.749
	6 CASE2	15	14.438	57.992	0	0	0	2.247
		16	-14.438	121.96	0	0	0	-149.373
	7 CASE3	15	34.686	109.288	0	0	0	92.209
		16	-34.686	70.664	0	0	0	-3.372
	8 CASE4	15	17.518	47.591	0	0	0	-11.187
		16	-17.518	123.943	0	0	0	-164.425
	9 CASE5	15	42.828	111.711	0	0	0	101.266
		16	-42.828	59.823	0	0	0	18.076
	10 CASE6	15	18.141	15.765	0	0	0	-29.157
		16	-18.141	87.155	0	0	0	-135.042
	11 CASE7	15	43.451	79.885	0	0	0	83.296
		16	-43.451	23.035	0	0	0	47.459
22	5 CASE1	13	63.727	-29.125	0	0	0	-47.97
		17	-63.727	29.125	0	0	0	-49.599
	6 CASE2	13	37.404	-8.658	0	0	0	-29.839
		17	-37.404	8.658	0	0	0	0.834
	7 CASE3	13	64.493	-37.884	0	0	0	-46.947
		17	-64.493	37.884	0	0	0	-79.965
	8 CASE4	13	34.269	-4.653	0	0	0	-26.515
		17	-34.269	4.653	0	0	0	10.927
	9 CASE5	13	68.13	-41.185	0	0	0	-47.9
		17	-68.13	41.185	0	0	0	-90.071
	10 CASE6	13	13.773	4.529	0	0	0	-11.64
		17	-13.773	-4.529	0	0	0	26.813
	11 CASE7	13	47.634	-32.003	0	0	0	-33.025
		17	-47.634	32.003	0	0	0	-74.186
23	5 CASE1	14	71.066	5.606	0	0	0	10.299
		18	-71.066	-5.606	0	0	0	8.482
	6 CASE2	14	60.56	23.791	0	0	0	39.627
		18	-60.56	-23.791	0	0	0	40.073
	7 CASE3	14	53.212	-14.783	0	0	0	-23.084
		18	-53.212	14.783	0	0	0	-26.439

	8							
	CASE4	14	62.259	28.384	0	0	0	46.915
		18	-62.259	-28.384	0	0	0	48.17
	9							
	CASE5	14	53.075	-19.834	0	0	0	-31.475
		18	-53.075	19.834	0	0	0	-34.97
	10							
	CASE6	14	39.209	26.683	0	0	0	43.843
		18	-39.209	-26.683	0	0	0	45.546
	11							
	CASE7	14	30.025	-21.535	0	0	0	-34.547
		18	-30.025	21.535	0	0	0	-37.594
	5							
24	CASE1	15	71.066	-5.606	0	0	0	-10.299
		19	-71.066	5.606	0	0	0	-8.482
	6							
	CASE2	15	53.212	14.783	0	0	0	23.084
		19	-53.212	-14.783	0	0	0	26.439
	7							
	CASE3	15	60.56	-23.791	0	0	0	-39.627
		19	-60.56	23.791	0	0	0	-40.073
	8							
	CASE4	15	53.075	19.834	0	0	0	31.474
		19	-53.075	-19.834	0	0	0	34.97
	9							
	CASE5	15	62.259	-28.384	0	0	0	-46.915
		19	-62.259	28.384	0	0	0	-48.17
	10							
	CASE6	15	30.025	21.535	0	0	0	34.547
		19	-30.025	-21.535	0	0	0	37.594
	11							
	CASE7	15	39.209	-26.683	0	0	0	-43.843
		19	-39.209	26.683	0	0	0	-45.546
	5							
25	CASE1	16	63.727	29.125	0	0	0	47.97
		20	-63.727	-29.125	0	0	0	49.599
	6							
	CASE2	16	64.493	37.884	0	0	0	46.947
		20	-64.493	-37.884	0	0	0	79.965
	7							
	CASE3	16	37.404	8.658	0	0	0	29.839
		20	-37.404	-8.658	0	0	0	-0.834
	8							
	CASE4	16	68.13	41.185	0	0	0	47.9
		20	-68.13	-41.185	0	0	0	90.072
	9							
	CASE5	16	34.269	4.653	0	0	0	26.515
		20	-34.269	-4.653	0	0	0	-10.927
	10							
	CASE6	16	47.634	32.003	0	0	0	33.025
		20	-47.634	-32.003	0	0	0	74.186
	11	16	13.773	-4.529	0	0	0	11.64

	CASE7							
		20	-13.773	4.529	0	0	0	-26.813
	5							
26	CASE1	17	29.125	63.727	0	0	0	49.599
		18	-29.125	53.6	0	0	0	-26.307
	6							
	CASE2	17	76.458	37.404	0	0	0	-0.834
		18	-76.458	56.458	0	0	0	-42.99
	7							
	CASE3	17	37.884	64.493	0	0	0	79.965
		18	-37.884	29.369	0	0	0	0.82
	8							
	CASE4	17	89.403	34.269	0	0	0	-10.927
		18	-89.403	60.15	0	0	0	-48.599
	9							
	CASE5	17	41.185	68.13	0	0	0	90.071
		18	-41.185	26.289	0	0	0	6.163
	10							
	CASE6	17	80.221	13.773	0	0	0	-26.813
		18	-80.221	42.879	0	0	0	-40.131
	11							
	CASE7	17	32.003	47.634	0	0	0	74.186
		18	-32.003	9.018	0	0	0	14.63
	5							
27	CASE1	18	23.518	17.466	0	0	0	17.825
		19	-23.518	17.466	0	0	0	-17.825
	6							
	CASE2	18	52.667	4.102	0	0	0	2.917
		19	-52.667	23.843	0	0	0	-25.619
	7							
	CASE3	18	52.667	23.843	0	0	0	25.619
		19	-52.667	4.102	0	0	0	-2.917
	8							
	CASE4	18	61.019	2.108	0	0	0	0.429
		19	-61.019	26.785	0	0	0	-28.807
	9							
	CASE5	18	61.019	26.785	0	0	0	28.807
		19	-61.019	2.108	0	0	0	-0.429
	10							
	CASE6	18	53.538	-3.67	0	0	0	-5.415
		19	-53.538	21.007	0	0	0	-22.964
	11							
	CASE7	18	53.538	21.007	0	0	0	22.964
		19	-53.538	-3.67	0	0	0	5.415
	5							
28	CASE1	19	29.125	53.6	0	0	0	26.307
		20	-29.125	63.727	0	0	0	-49.599
	6	19	37.884	29.369	0	0	0	-0.82

CASE2							
	20	-37.884	64.493	0	0	0	-79.965
7							
CASE3	19	76.458	56.458	0	0	0	42.99
	20	-76.458	37.404	0	0	0	0.834
8							
CASE4	19	41.185	26.289	0	0	0	-6.163
	20	-41.185	68.13	0	0	0	-90.072
9							
CASE5	19	89.403	60.15	0	0	0	48.599
	20	-89.403	34.269	0	0	0	10.927
10							
CASE6	19	32.003	9.018	0	0	0	-14.63
	20	-32.003	47.634	0	0	0	-74.186
11							
CASE7	19	80.221	42.879	0	0	0	40.131
	20	-80.221	13.773	0	0	0	26.813

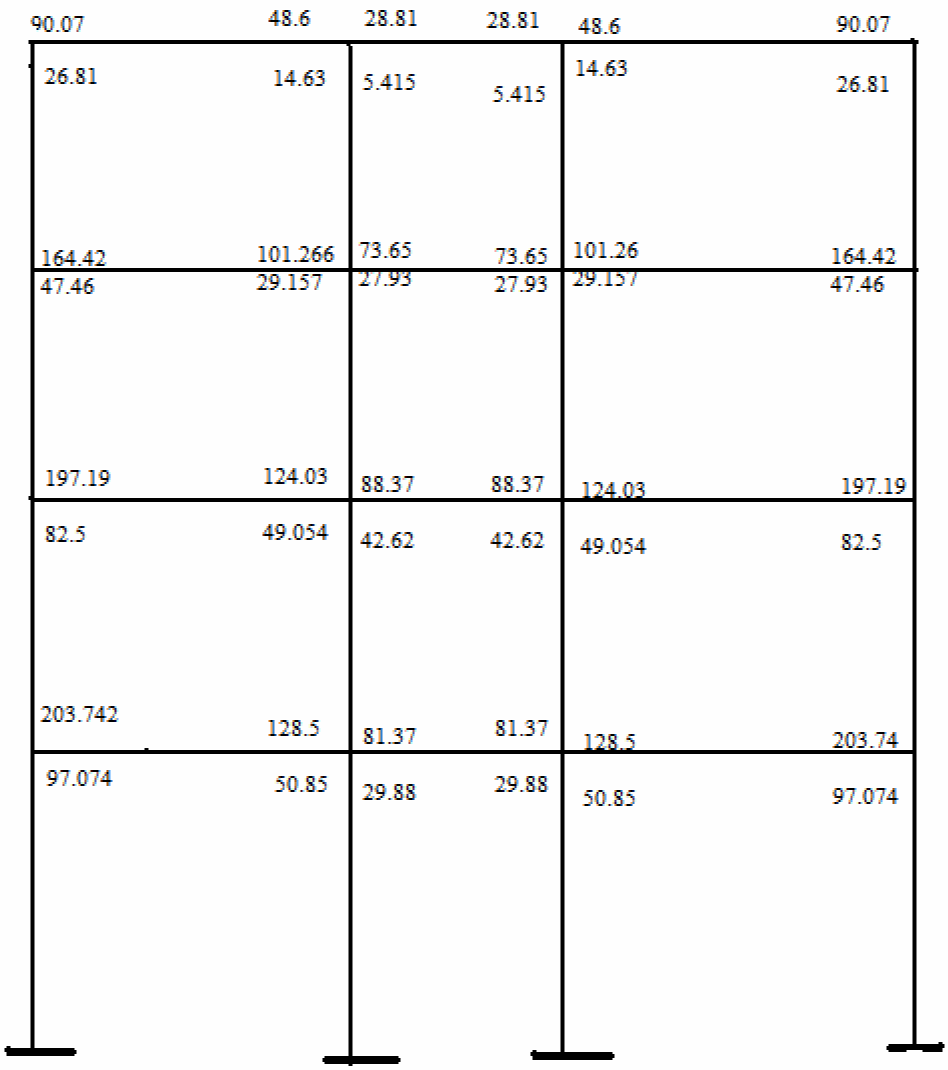

Fig:4.2 The maximum design hogging(above) and sagging(below) moments of beams in all combinations

LONGITUDINAL REINFORCEMENT PROVIDED FOR THE BEAMS:

The size of the beam = 300x450

Effective depth d= 450-25-(25/2) =421.5mm ϕ

Effective cover d^1= 25+(25/2)

From Table D,SP 16:1980,

We get $M_{u,lim}/bd^2$ = 2.76

$M_{u,lim}$=140.88 kN-m

Considering beam 5, the hogging moment at joint 5 M =203.745kN-m

$M>M_{u,lim}$, hence it is doubly reinforced.

We get d^1/d = 0.1,

M/bd^2=3.99, from Table 50,SP 16:1980,

The percentage of reinforcements at top and bottom are P_T=1.337 and P_B=0.401--------(1)

The sagging moment at joint 5, M^1= 97.074 kN-m

$M^1<M_{u,lim}$, hence singly reinforced. M^1/bd^2=1.90

From table 2 , SP 16:1980 ,we get P_B= 0.602 ------------------(2)

From (1) and (2), the maximum values are taken and the reinforcement is found.

Required $A_{st\ (top)}$ =1654.53 mm^2 , $A_{st(bottom)}$= 744.975 mm^2

The provided reinforcements are

Top, A_{st} = 1884.9 mm^2, 6 bars @20mm ϕ and bottom, A_{st}=804.25, 4bars @16mm ϕ .

Thus the provided longitudinal reinforcements are found for the other beams.

From the reinforcements provided the moment capacities of the beams are calculated.

MOMENT CAPACITIES OF THE BEAMS:

Hogging moment capacity:

$M_{U,lim} = 0.36 *(X_{u,max}/d)[1-0.42(X_{u,max}/d)]bd^2 f_{ck}$

$= 140.3$ kN m

Steel corresponding to this moment, $A_{st1} = (0.48*0.36*f_{ck}*bd)/0.87f_y$

$= 1184.54\ mm^2$

Considering the beam 5,

Available $A_{st2} = A_{st} - A_{st1}$

$= 1884.95 - 1184.54 = 700.41\ mm^2$

Additional moment capacity due to available compression steel

$M_2 = A_{sc}*f_{sc}(d-d^1)/10^6 = 106.46$kN-m

$(A_{sc}*f_{sc})/(0.87*f_y) = 786.3mm^2$

But available $A_{st2} = 700.41$

Hence flexural moment contribution for $700.41mm^2$ is ,

$M_2 = 0.87*415*700.41*(412.5-(25+25/2))/10^6$

$= 94.83$ kN-m

Total hogging moment capacity,

$M = M_{U,lim} + M_2 = 233.75$ kN-m

If the value of $A_{st} < A_{st1}$,

$M = 0.87f_y(A_{st}/bd)[1-(1.005f_{ck}/f_y)(A_{st}/bd)]bd^2$

Sagging moment capacity:

The sagging action of the beam near supports will cause the monolithically constructed slab to act as the flange of T-beam, contributing additional compressive force, thus increasing the flexural capacity.

$A_{st} = 804.25mm^2$

$B_f = l_o/6 + b_w + 6D_f = 1556.67$mm

$X_u = (0.87*f_y*A_{st})/(0.36*f_{ck}*b_f)$

$= 25.9 < 120$

$M_u = 0.87*415*A_{st}*d[1-(A_{st}*f_y/b_f*d*f_{ck})]/10^6 = 116.7$kN-m

The hogging and sagging capacities of beams are as below:

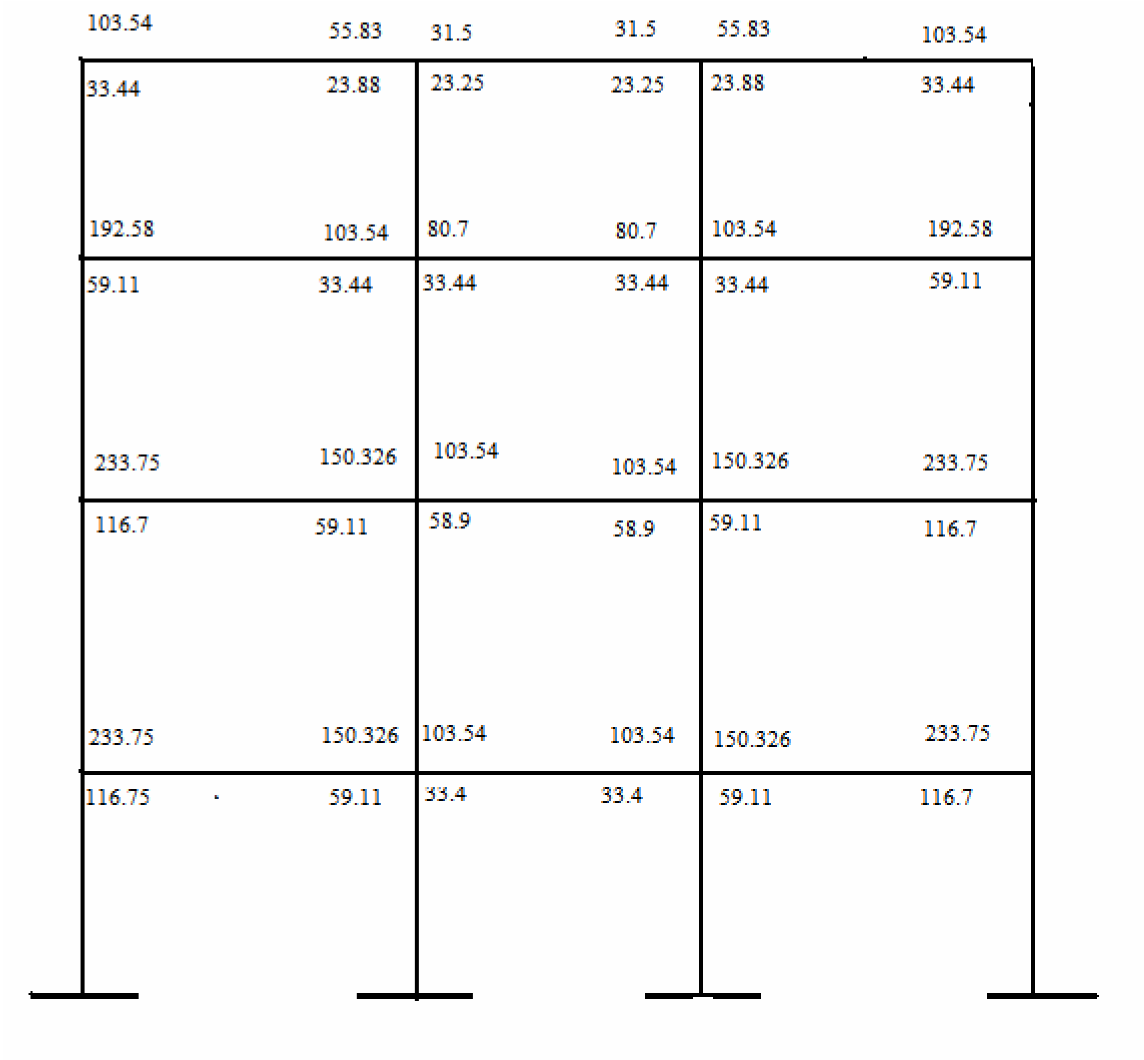

Fig:4.3 The hogging and sagging moment capacities of the beams

To eliminate the possibility of the column sway mechanism during the earthquake, it is essential that the plastic hinges should be formed in the beams. This is achieved after moment capacity verification of columns with capacity of beams at every joint of the frame. The amount, by which the design moments of columns at a joint are to be magnified, is achieved by the magnification factor determination at that particular joint.

DETERMINATION OF MOMENT MAGNIFICATION FACTOR:

The sum of the resisting moments of the columns, taking into account the action of axial forces should be greater than the sum of resisting moments of all adjacent beams for each seismic action.

$$|M^O_{R1}|+|M^U_{R1}| >= \lambda_{Rd} |M^l_{R1}| +|M^r_{R1}|$$

$$|M^O_{R2}|+|M^U_{R2}| >= \lambda_{Rd}|M^l_{R2}|+|M^r_{R2}|$$

Where λ_{Rd} is the factor which takes into account the variability of the yield stress f_y and the probability of strain hardening effects in the reinforcement or is known as the over strength factor. It is taken according to EC8 for seismic ductility class high. Therefore, the capacity based design is satisfied if the columns are designed for the following moments:

$$M_{s1,cd} = \alpha_{cd\,1} M_{s1}$$

$$M_{s2,cd} = \alpha_{cd2}\ M_{s2}$$

Where $\alpha_{cd} = \lambda_{Rd} [|M^l_R|+|M^r_R|/|M^O_R|+|M^U_R|]$

$M^l_{R1,2}$, $M^r_{R1,2}$, $M^O_{R1,2}$,$M^U_{R1,2}$ are the resisting moments of the left and right beams and design moments of the over and under columns at joint in seismic directions 1 and2. α_{cd} is the moment magnification factor and $M_{s,cd}$ is the magnified moment of the column at that joint.

If the sum of column moments is greater than that of the beams, there is no need to magnify the column moments. The magnification factor in such case is taken as unity.

The moment magnification factors at all joints:

Joint no:	Seismic direction	Sum of resisting moments of beam with overstrength factor 1.35	Sum of the resisting moments of columns.	Moment magnification factor
5,8	1 2	157.545 315.56	203.543 203.543	1 1.55
6,7	1 2	248.02 219.58	145.513 145.513	1.71 1.51
9,12	1 2	157.545 315.56	197.194 197.194	1 1.6
10,11	1 2	282.45 219.58	155.23 155.23	1.82 1.4
13,16	1 2	79.8 259.98	164.425 164.425	1 1.58
14,15	1 2	184.87 154.035	117.78 117.78	1.57 1.31
17,20	1 2	45.144 139.8	90.071 90.071	1 1.55
18,19	1 2	74.76 106.76	62.259 62.259	1.2 1.7

Table :4.1 Moment Magnification factors

After obtaining the magnification factors, the flexural strengths are to be increased accordingly at every joint and the maximum revised moment from top and bottom is to be considered for design and the axial load obtained from analysis.

DETERMINATION OF LONGITUDINAL REINFORCEMENT IN COLUMNS:

Columns size = 300x530mm

Effective cover d^1= 40 +(20/2)=50 mm (d^1/D = 0.1)

Effective depth d =530-50=480mm

Considering the columns 1&4 ,

Axial force P_U = 464.210KN

Maximum moment M_U= 208.96 KN-m

$P_U/f_{ck}bD$ = 0.146

$M_U/f_{ck}bD^2$ = 0.124

From chart 44 of SP 16:1980 (d^1/D=0.1 , f_y=415)

We get, p/f_{ck} = 0.07

Thus A_{st} = 2226mm^2, provide 8no.s of 20mm ϕ bars.In this way the vertical reinforcements are calculated.

CAPACITY DESIGN FOR SHEAR IN BEAMS:

The design shear forces in beams are corresponding to the equilibrium condition of the beam under the appropriate gravity load and to end resisting moments corresponding to the actual reinforcement provided, further multiplied by a factor γ_{Rd}. This factor compensates the partial safety factor applied to yield strength of steel and to account the strain hardening effects. Generally this value is taken as 1.25.

The shear force is in both the directions is determined by the following equation.

$V_{A,S1} = wl/2 - \gamma_{Rd} (M_{AR}+M^1_{BR})/l$

$V_{B,S1} = wl/2+ \gamma_{Rd} (M_{AR}+M^1_{BR})/l$

$V_{A,S2} = wl/2 + \gamma_{Rd} (M^1_{AR}+M_{BR})/l$

$V_{B,S2} = wl/2 - \gamma_{Rd} (M^1_{AR}+M_{BR})/l$

Where $M_{AR}, M_{BR}, M^1_{AR}, M^1_{BR}$ are the actual resisting moments at hinges and γ_{Rd} is the amplification factor , w comprises of the dead and live load.

The reinforcement is determined for the maximum of the above four at a particular joint.

Beam no:	Maximum shear force
5,7	95.88
6	86.975
12,14	95.88
13	100.8
19,21	77.72
20	74.76
26,28	43.125

27	34.82

Table :4.2 Maximum shear force in beams

Provide a nominal reinforcement of 2 legged, 8mmϕ @250mmc/c in all the beams.

Provide special confinement reinforcement at the joint for a length of 2d=2*421.5$\approx$830mm. Provide 8mmϕ @100mm c/c.

DETERMINATION OF SHEAR FORCE IN COLUMNS:

The capacity design shear forces are evaluated by considering the equilibrium of column under the actual resisting moments at the ends. It is given by:

$V= \lambda_{Rd} (M_{C,Rd} + M_{D,Rd})/l$

Where $M_{C,Rd}$ and $M_{D,Rd}$ are the flexural capacities of the end sections, l is the clear height of the column and $\lambda_{Rd} = 1.35$.

The shear capacity of the columns in the frame:

Column no:	Capacity based shear(kn)
1,4	141.05
2,3	67.44
8,11	150.96
9,10	125.31
15,18	148.387
16,17	216.69
22,25	112.51
23,24	64.276

Table :4.3 Shear capacity of columns

For columns provide a nominal reinforcement of 8mmϕ2 legged stirrups @ 300mm c/c.

Special confining reinforcement:

This will be provided over a length of l_o towards mid span of column.

$$L_0 > \begin{cases} D \\ l/6 \\ 450mm \end{cases} \quad \text{whichever is greater =600mm.}$$

The spacing should not exceed 100mm and should be greater than ¼ of minimum dimension.

S> 75mm and <100mm.

Minimum area of cross section of hoop reinforcement,

A=0.18*S*h*(fck/fy)*(Ag/Ak-1)=0.18*75*220*(20/415)*((530*300)/(480*240)-1)

=54.54mm2.   Use 10mm ϕ bars at a spacing of 90mm c/c.

Chapter 5

Conclusion

CONCLUSION:

The design of a G+3 RC frame building is done on the basis of Capacity based design.
At present capacity based design concept is applied for the solution of a soft storey problem with a view to avoid the concentration of ductility demand in soft storey elements by distributing it throughout the structure by proportionate design of strong column weak beam structure as the main cause for the failure of soft storey is the column sway mechanism. The possibility of failure can be eliminated by this method of strong column weak beam.

Chapter

References

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SUMMARY:

ANALYSIS AND CAPACITY BASED EARTHQUAKE RESISTANT DESIGN OF A MULTI BAY MULTI STOREY R.C FRAME:

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Abstract:

The main cause of failure of multi-storey multi-bay reinforced concrete frames during seismic motion is the soft storey sway mechanism or column sway mechanism. If the frame is designed on the basis of strong column-weak beam concept the possibilities of collapse due to sway mechanisms can be completely eliminated. In multi storey frame this can be achieved by allowing the plastic hinges to form, in a predetermined sequence only at the ends of all the beams while the columns remain essentially in elastic stage and by avoiding shear mode of failures in columns and beams. This procedure for design is known as Capacity based design

Introduction:

Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. In case of earthquake forces the demand is for ductility. Ductility is an essential attribute of a structure that must respond to strong ground motions. Larger is the capacity of the structure to deform plastically without collapse, more is the resulting ductility and the energy dissipation. This causes reduction in effective earthquake forces. Hence based on the three criteria strength, stiffness and ductility the methods for seismic design are described below:

LATERAL STRENGTH BASED DESIGN

DISPLACEMENT BASED DESIGN

CAPACITY BASED DESIGN

ENERGY BASED DESIGN

Problem statement:

Floor plan of a public cum office building is given. The plan is regular and has all columns equally placed. The building space frame is divided into a number of frames. An interior frame 4-4 is considered for the analysis and design.

Analysis:

The analysis of the frame for the given loading is done by STAAD PRO-2004. The results are found for 7 load combinations and the maximum values in all combinations are considered for the design.

Design Procedure:

1. The beams are designed for the maximum values obtained from the analysis.
2. Reinforcements are provided according to SP:16(1980).
3. The maximum hogging and sagging moment capacities of beams are calculated.
4. Moment magnification factors are calculated for each joint.
5. The column moments are revised according to the moment magnification factors.
6. Reinforcements are provided for the columns according to the revised moment and design axial forces.
7. Maximum shear capacity and reinforcements are calculated for the beams and columns.

Results:

The moment capacities and reinforcement details are provided for the given frame.

Conclusion:

The design of a G+3 RC frame building is done on the basis of Capacity based design.

At present capacity based design concept is applied for the solution of a soft storey problem with a view to avoid the concentration of ductility demand in soft storey elements by distributing it throughout the structure by proportionate design of strong column weak beam structure.

References:

1. Earthquake resistant design of structures - Pankaj Agarwal and Manish Shrikhande
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