"ELASTIC ANALYSIS OF TALL REINFORCED CONCRETE FRAMES ON ELASTIC SUB-BASE"

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ABSTRACT

Frames of high-rise structures act as load-bearing construction for these tall buildings. They carry and distribute load that are acting on them to their foundations. The distribution pattern of these load play a very important role in the behaviour of the frames. They are normally assumed as resting on rigid sub-base, compacted hard-core. This is not true. They usually deflect downwards. In actual sense they normally rest on elastic sub-base a situation that reflects reality on sites. The sub-base model on which the building is resting also contribute to the way the whole structure behave. This paper examines the winkler model and the behavior of 11storey Reinforced Concrete Frames resting on rigid sub-base and on elastic sub-base. The achieved results are very remarkable.

INTRODUCTION

One of the types of structural load- bearing constructions are frame system (fig. 2 &. 3). They carry on their foundations vertical loads (Dead and imposed Loads) (Fig. 2 &. 3). Usually, it is assumed that the foundations lie on non-deformable sub-base (Fig. 2). In real practice, however, there is always elastic settlement of the sub-base and the deflection of the foundations. This paper deals with reinforced concrete high rise frames (11-storeys) on rigid strip foundation and those frames on elastic sub- base (Fig, 3,). The internal forces from these frames give remarkable results. Consideration of these settlements, of statically in determinate frames, usually lead to vital changes in the distribution of internal forces in the structural members as well as in their deflections.

Presently, there is lack of procedure of statical analysis of frame systems that take into consideration elastic deformation f sub-base. Also the knowledge the magnitude of the influence of the deflection on such structure is non-existence. For these reason, the above topic is well-aimed and forms the basis for this design of structures.

The main objective, here is to find out about the behaviours of.

The R.C. high – rise structure (11-storeys) on rigid strip foundations. (Fig. 2)

The R.C. high – rise structure (11-storeys) on strip foundations on elastic sub-base (fig 3)

The latter, it is believed reflects the real activities under these frames on construction sites. Non-consideration of the latter in design today makes the design faulty.

METHODOLOGY

Su –base: the sub-base is assumed elastic according to E. Winkler's assumptions. In that assumption, there is only one parameter in form of coefficient of

flexibility $k\left(\frac{T}{m^3}\right)$

Gorbunow - posadow and other researchers (4,5,6). Describe the coefficient (k) for elastic sub – base as follows;

$$k = \frac{P}{A} * \frac{1}{\delta} \quad (1)$$

Where: P, = load acting on a rigid slab, pressed into the soil,

A. = Area of the pressed slab,

δ = vertical deflections (settlements) of sub – base (soil) under the slab.

The equation denotes the basis for research approach in describing the value of the coefficient (k).

Beam on one- parameter elastic sub- base:

The basic differential equation is

$$EI\frac{dy^4}{dx^4} = q(\times) \quad (2)$$

In the case of sub - base pressure

$$q(\times) = P(\times) - g(\times) \quad (3)$$

Where;

P (x) = external pressure due to uniformly distributed loads.

g(x) = Intensity of the sub- base pressures.

Assuming a one - parameter sub - base (Winkler)

$$g(\times) = k.y \quad (4)$$

$$\text{where}; k = k_0 * b \quad (5)$$

Where; k_o (KG/cm^3) = Coefficient of sub- base settlement.

b(cm) = Width of beam.

Taking the above into consideration, the eqn. (2) now takes the form;

$$EI = \frac{dy^4}{dx^4} + k.y = p(\times) \quad (6)$$

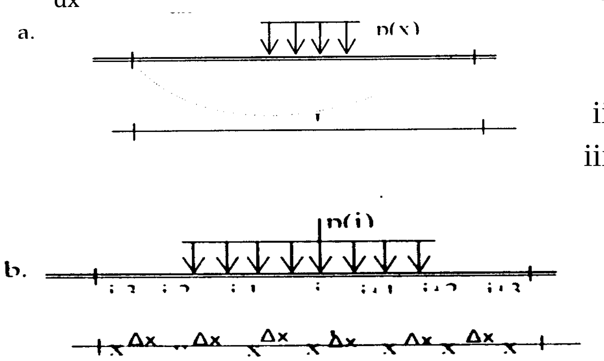

Fig.1. principles of beam on elastic sub –base.

a. Settlement of beam –axis
b. Beam on elastic sub – base using finite difference method.

Frame analysis: The calculation of R.C high – rise frames (11 –storeys) on rigid strip foundation (k-∞) fig. 2 and elastic strip foundation $\left(k = 1500\frac{T}{m^3}\right)$ fig 3 is a complex assignment. It involves the analysis of indeterminate systems on elastic support. The loads include;

a. Dead + imposed load $\frac{T}{m}$
b. Wind load distributed from 0.77T to 0.95T. The methods adopted for the analysis of the frames include:

- Slope deflection equation in matrix from:
- Guldan method in the formation of equation of equilibrium at joints.
- Computer program (LG-2) development to make work easier and simpler

The methods used here include;

Research findings: Figures 2 and 3 illustrate the statically diagrams of the vertical extreme load combinations with the worst leading patterns. Also the Figures show frames on rigid foundation (K=∞) and frames on strip footings on elastic sub – base ($k - 1500\frac{T}{m^3}$) respectively. The following observation are worth mentioning; but due to the voluminous nature of the results presentation is limited to the vertical loaded frames. Only frames (11 storeys) on strip foundations were sub- divided into:

i. R.C frame on elastic foundation $\left(k = 1500\frac{T}{m^3}\right)$
ii. R.C frame on rigid foundation (k-∞)
iii. Strip (Beam) on elastic sub- base $\left(k = 1500\frac{T}{m^3}\right)$

Tables (01) on its own part illustrate the Bending moment of frames on rigid strip foundations (k-∞) and those of frames on strip foundations based on elastic sub - base $\left(k = 1500\frac{T}{m^3}\right)$ loaded vertically. The following observations are worth mentioning;

Finding: Paper exposes the inadequacies in structural analysis. It shows that the assumption that the sub-base is rigid and does not deflect during the structural analysis is faulty:

i. Soil mechanics, also is full (If many faulty assumptions. The issue of uniform pressure distribution under the sub-base is also full of mistakes.

ii. The internal forces, such as bending moments, shearing forces and stresses used to design number of member- bars, and sizes are usually different from the designed ones during constructions.

iii. Presently the practice is to conduct soil investigation calculate the load bearing capacity, compact the sub-base and then construct the structure. Assumptions is then made that the building is stable. The sub – base is then assumed vertically non-deformable. This is far reaching assumption. Structures usually deform vertically during construction on sites.

iv. Compaction before construction is usually a very complex job. It is never done well.

v. Even, in many cases, there are usually non-linear deformations.

vi. All internal forces, both bending moments and shearing forces and stresses are normally redistributed during constructruction on sites.

vii. The redistributed forces differ considerably in all the frame – members comparing the frames on rigid sub-base. (fig.5) and frame on elastic sub-base (fig. 4). The figures 4 and 5 illustrate the bending moment’s diagrams of these frames.

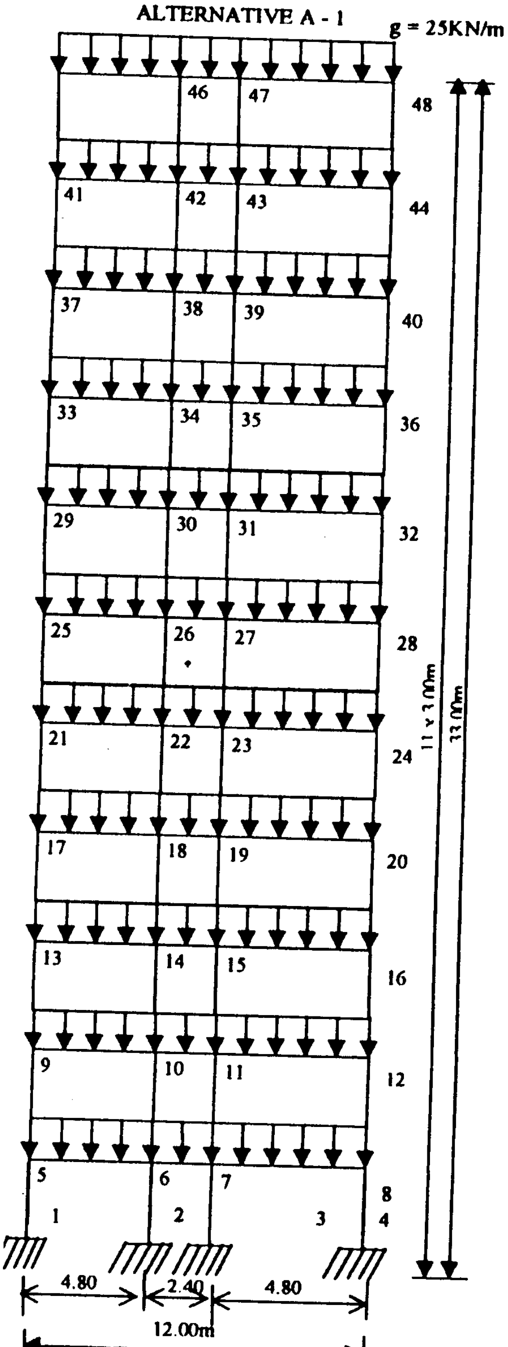

FIG 2: Vertically Loaded frame on rigid strip foundation (k = ∞)

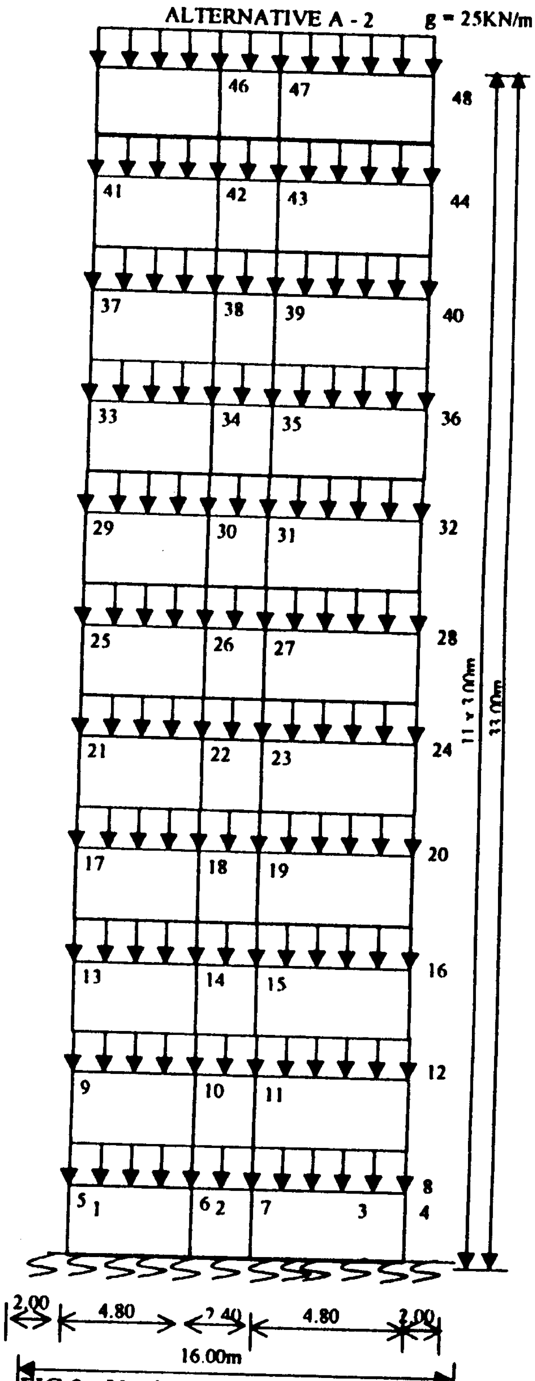

FIG 3: Vertically Loaded frame on strip foundation on elastic sub-base (k = 1500T/m^3)

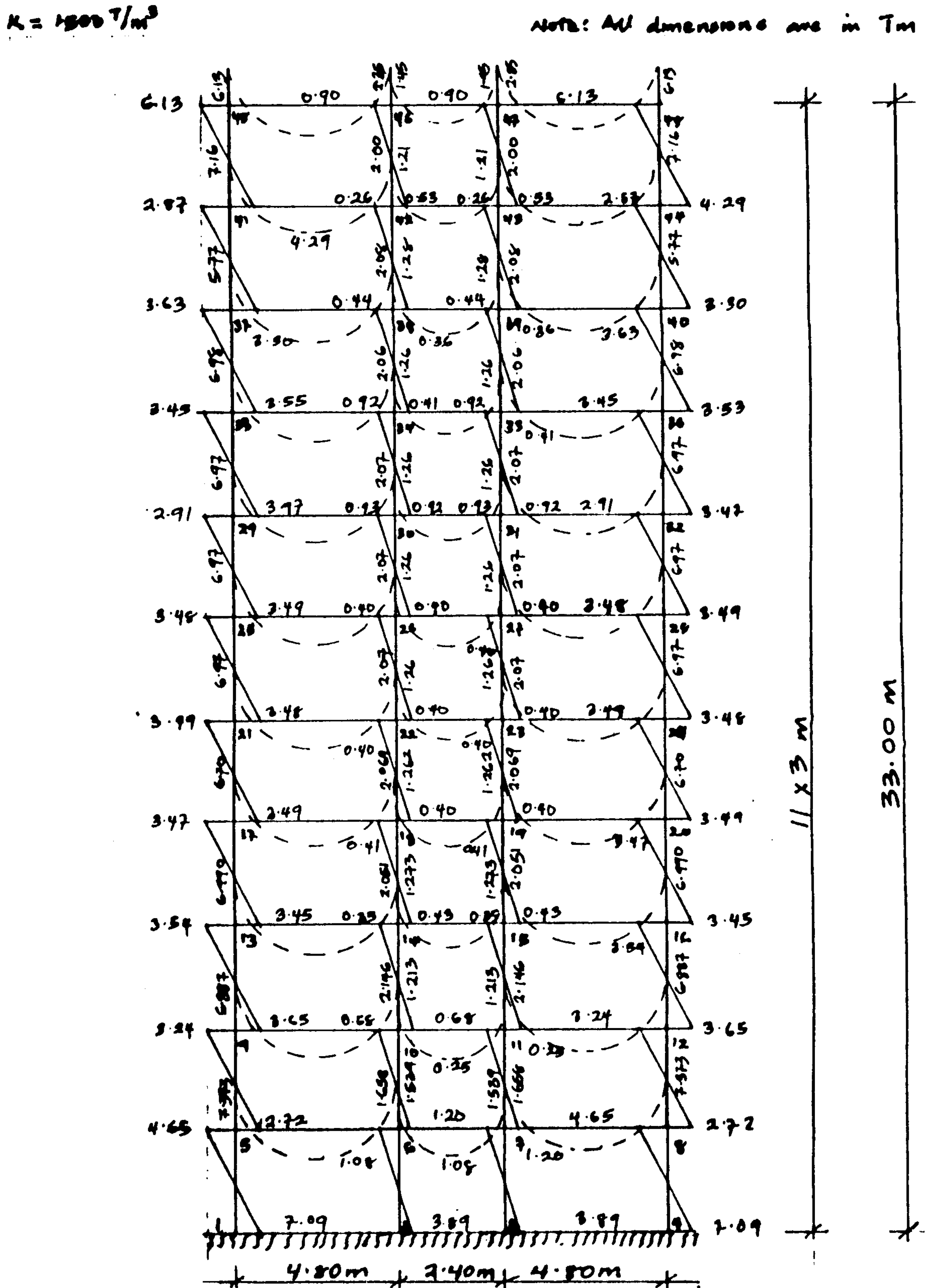

Fig. 4: Reinforced Concrete frame on elastic sub-base

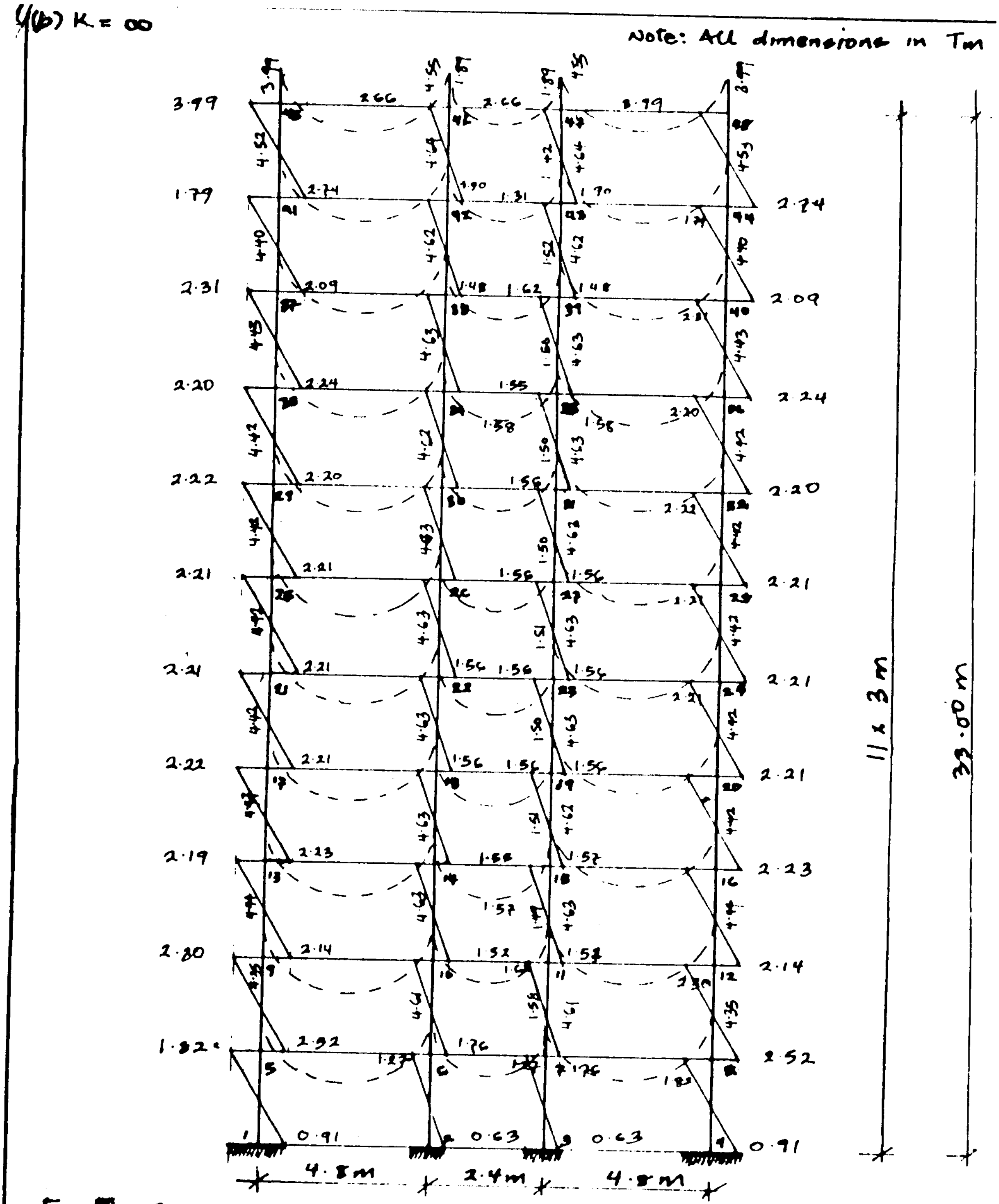

Fig. 5. Reinforced concrete frame on rigid strip foundation

CONCLUSION AND RECOMMENDATION

Table 1 reveals that the bending moment in the frames with rigid foundation on elastic sub-base. The paper proves that during construction of buildings, there is always a redistribution of inner forces.

These redistributed forces were usually not considered design.

The enormous redistribution is shown in fig.4 & fig 5. The percentage difference between some selected structural members are shown in table 1 below

Table 1: redistributed bending moments – vertical loads only

S/No	Member	Bending	K = ∞ in relation to k =1500T/m^3				Remarks
		Moment (KN-m)	K = ∞	100	K=1500	%	
1	Columns (1-5&4-8)	M_{1-5}–M_{4-8}	0.9131	100	7.0931	777	Enormous redistribution
2	Columns (9-13 & 1216)	M_g-13-M_{12-16}	2.1370	100	3.5466	171	
3	Columns (42-38&43-39)	M_{42-38}-M_{43-39}	1.3149	100	0.2621	20	
4	Beam (5-6&7-8)	M_{5-6}-M_{7-8}	4.3476	100	7.3729	170	
5	Beam (21-22&24-23)	M_{21-22}-M_{24-23}	4.4216	100	6.9695	158	
6	Beam (45-46&48-47)	M_{45-46}-M_{48-47}	3.9860	100	6.1264	154	

It is, therefore, necessary to tae the elastic phenomenon of the sub-base into consideration in design. On the construction sites, all the designed internal forces are usually redistributed within the structural members. The difference can be enormous in some members. (e.g. members 1-5 in fig 4 and member 1-5 in fig 5). This research requires further investigation. It is a new structural approach to the structural analysis and design of structures.

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