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" توزيع الاحمال على المنشآت ذات النظام الانبوبي المتداخل "

LOAD DISTRIBUTION FOR TUBE IN TUBE STRUCTURAL SYSTEM

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ملخص البحث :-

تعتبر المنشآت العاليه ذات النظام الانبوبي المتداخل من اكثر الانظمه الانشائيه كفاءه في مقاومة الاحمال الجانبيه . وترجع كفاءة هذا النظام الانشائي الى العدد الكبير من الوصلات الجاسئه للاطار الانبوبي الخارجي هذا بالاضافه الى جساءة القلب الخرساني والمكون من حوائط قص . وحيث أن سلوك وتحليل مثل هذه المنشآت تكون غايه في الصعوبه . الامر الذي يتطلب استخدام أجهزة كمبيوتر ذو سرعه عاليه وسعه كبيره لتحليل مثل هذه المنشآت . ثم أن تحليل هذه المنشآت باستخدام الكمبيوتر يحتاج الى وقت طويل وبرامج خاصه غير متوافره في كثير من الاحيان . لذا كان من الضروري ايجاد طريقه مبسطه لتوزيع الاحمال بين أجزاء هذا النظام الانبوبي المتداخل . وتعتمد هذه الطريقه على معرفة الجساءه النسبيه لكل جزء من أجزاء النظام الانبوبي المتداخل ثم يتم توزيع الاحمال بحيث يكون نصيب كل جزء من الحمل الكلي يتناسب مع نسبة جساءة كل جزء من الجساءه الكليه للمنشأ الانبوبي . وقد أثبتت هذه الطريقه المذكوره في هذا البحث سهولة الاستخدام وتحديد نصيب كل جزء من الاحمال الجانبيه وبالتالي تصميم كل جزء من أجزاء النظام الانبوبي المتداخل بمفرده .

ABSTRACT

The tube in tube structure is one of the most efficient system for resisting lateral loads. The efficiency of this system is derived from great number of rigid joints of the exterior framed tube in addition to the interior shear wall bending rigidity[1]. To make an approximate analysis for preliminary design of this structural type, the three dimensional analysis for the tube in tube system and each component (core shear wall and exterior framed tube) under uniform lateral loads are presented. Based on knowing the lateral displacement from computer results, the average lateral loads that resisted by each part of the tube in tube system are derived as a function of the stiffness ratio (each part stiffness relative to the overall tube in tube stiffness). Also, the distribution of the average lateral loads through the height of each part are estimated as a function of the building height. The results of this method proved that it is simple and ease way for

estimating the lateral loads distribution between the exterior framed tube and interior core shear wall and then, each part can be designed separately. The lateral load distribution between the core shear wall and the exterior framed tube are presented.

INTRODUCTION

Because of the demand for column-free office space, it is then a natural solution to eliminate all interior supports and provide closely spaced exterior columns, thus creating a framed tube and use a shear wall closing the entire service core[2]. The resulting structural system consists of an inner tube created by the shear walls and the outer tube consisting of the closely spaced column system, the two systems connected together by the floor slabs creating what may be called a tube in tube system Fig.(1).

The tube in tube system has the advantage of both the framed tube structure as well as the shear wall type structure. In fact, the core shear wall inner tube greatly enhances the structural characteristics of the exterior framed tube by considerably reducing the shear displacement of the columns of the framed type. The tube in tube structure subjected to lateral loads will primarily act as a shear wall-frame interactive system, interaction being between the interior shear wall tube and the sides of framed tube parallel to the direction of the lateral loads[3]. For approximate analysis of the shear wall-frame interaction type behaviour of this system, one of the most direct approaches would be to estimate the lateral loads distribution between the two individual systems. Then, the two individual systems shear wall and framed tube can be designed separately.

ANALYSIS TECHNIQUE

To derive the interaction lateral loads between the two individual system shear wall and framed tube, the shear displacement for each individual system and for the tube in tube system that combines the same shear wall and the framed tube must be estimated. After knowing the shear displacement, it can estimate the average load ratio that are resisted by each individual system. The average resisted lateral load can be calculated as a function of the stiffness ratio of each part of the structural system, framed tube and core shear wall stiffness relative to overall stiffness for tube in tube system. Fig.(1) shows the plan of the tube in tube system in which, the shear wall has been located at the centroide of the framed tube structural system. The properties of the shear wall are kept the same for all cases.

LATERAL LOAD COEFFICIENTS

The properties of the structural system is taken as;
The framed tube aspect ratio = 1.0

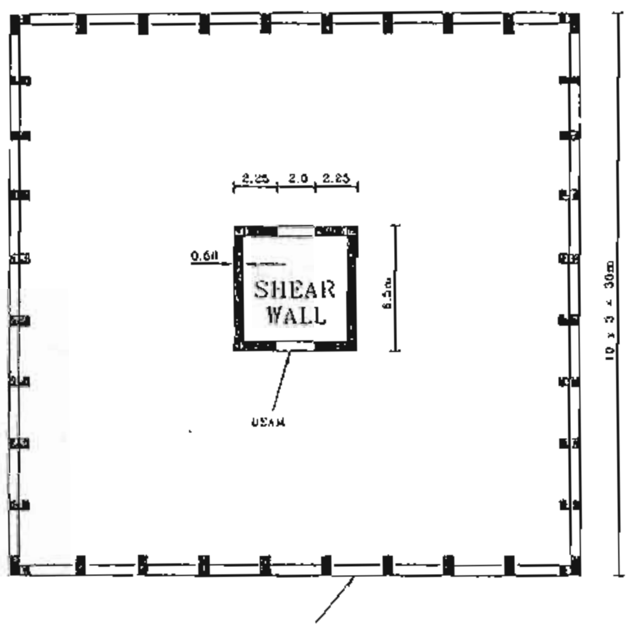

FIG. 1: THE PLAN OF THE TUBE IN TUBE SYSTEM

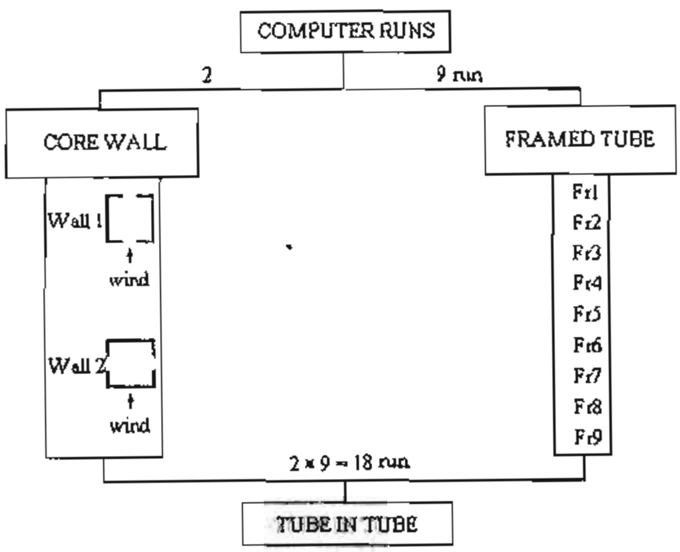

FIG.-2 THE FLOW CHART OF COMPUTER RUNS FOR ANALYZING TUBE IN TUBE.

The number of framed tube columns	=	36
The number of framed tube bays	=	36
The spacing between columns	=	3.0 m
The overall structural height	=	120 m
The uniform lateral pressure	=	0.1 t/m2

The properties of the core shear wall are kept the same for all computer runs and the dimensions of the connecting beams were 50 x 80 cm. The stiffness of the framed tube are taken as a variable parameter, so, the dimension of beams and columns of the framed tube system are changed and designated as Fr1, Fr2 ,Fr3.....Fr9. The parameters of the framed tubes (Fr1...Fr9) are given in Table (1)[4]. Fig.(2), shows the number of computer runs using "ETABS" computer program[5]. The tube in tube systems which consists of the framed tubes Fr1 to Fr9 in addition to core shear wall (1) were designated as Tube-1 to Tube-9. Also, the Tube-10 to Tube-18 were generated from framed tubes Fr1 to Fr9 and croe wall (2). In addition, two cases of the connecting beams for the core shear wall were studied.

The dimensions of these beams were 50 x 100 and 50 x 130 cm. The total number of runs for analyzing the tube in tube system equal 31 runs; i.e.; [9 framed tube only + 2 core shear wall + 18 tube in tube + 2 core shear wall for connecting beams]. After estimating the shear displacement of the coupled shear wall, framed tube and tube in tube structural system, the displacement ratio of each part of the tube in tube system (core shear wall and framed tube) relative to each story can be obtained. From these displacement ratios, the lateral load portion which are resisted by each part of the tubular system can be calculated. Hence, the average lateral load for each part of the tube in tube system (shear wall and exterior framed tube) can be obtained as a function of the stiffness ratio for each part of the tubular system. The values of the stiffness ratio and the average lateral load coefficient for each part of the tube in tube system are presented in Table (2).

GENERAL FORM FOR DISTRIBUTION OF LATERAL LOADS

From the values of the stiffness ratios and the average lateral loads, it can be estimate the interaction between the core shear wall and the exterior framed tube in resisting the lateral load as following:

$$Ww = Wt \cdot (Kw/Kt)^{N} \qquad \text{..........(1)}$$

$$Wf = Wt \cdot [1-(Kw/Kt)^{N}] \qquad \text{..........(2)}$$

Where; Ww = the distributed lateral load resisted by core shear wall. Wf = the distributed lateral load resisted by the framed tube system. Wt = the total uniform lateral load resisted by the tube in tube system. Kw = the stiffness of the core shear wall. Kt = the total stiffness of tube in tube system. N = the power of lateral load equation. By substituting the values of Ww, Wt, and the

TABLE (1) PROPERTIES OF BEAMS AND COLUMNS OF THE FRAMED TUBE SYSTEM

Framed tube	Column section		Beam section	
	Length	Width	Width	Depth
Fr1	1.00	0.60	0.60	0.80
Fr2	1.00	0.60	0.60	1.00
Fr3	1.00	0.60	0.60	1.30
Fr4	1.20	0.60	0.60	0.80
Fr5	1.20	0.60	0.60	1.00
Fr6	1.20	0.60	0.60	1.30
Fr7	1.50	0.60	0.60	0.80
Fr8	1.50	0.60	0.60	1.00
Fr9	1.50	0.60	0.60	1.30

TABLE - 2 THE STIFFNESS RATIO AND AVERAGE LATERAL LOAD COEFFICIENT FOR COUPLED SHEAR WALL AND FRAMED TUBE

system	Stiffness ratio		Average load coefficient	
	Shear wall	Framed tube	Shear wall	Framed tube
Tube-1	0.0290	0.9710	0.146	0.854
Tube-2	0.0241	0.9759	0.120	0.880
Tube-3	0.0211	0.9789	0.094	0.906
Tube-4	0.0260	0.9240	0.130	0.870
Tube-5	0.0215	0.9785	0.105	0.895
Tube-6	0.0181	0.9819	0.081	0.919
Tube-7	0.023	0.9770	0.121	0.889
Tube-8	0.0179	0.9821	0.091	0.909
Tube-9	0.0150	0.9850	0.068	0.932
Tube-10	0.0380	0.9620	0.187	0.813
Tube-11	0.0314	0.9685	0.128	0.872
Tube-12	0.0276	0.9724	0.100	0.900
Tube-13	0.0341	0.9659	0.177	0.823
Tuba-14	0.0275	0.9725	0.113	0.887
Tuba-15	0.0236	0.9764	0.087	0.913
Tube-16	0.0300	0.9700	0.120	0.880
Tubo-17	0.0235	0.9765	0.095	0.905
Tube-18	0.0196	0.9204	0.073	0.927

TABLE - 3 THE POWERS (N) OF THE LATERAL LOAD EQUATION RELATIVE TO EACH STIFFNESS RATIO OF COUPLED SHEAR WALL (Kw / Kt).

tube in tube system	Stiffness ratio Kw \ Kt	The power N
Tube-1	0.0290	0.542
Tube-2	0.0241	0.568
Tube-3	0.0211	0.613
Tube-4	0.0260	0.569
Tube-5	0.0215	0.587
Tube-6	0.0181	0.626
Tube-7	0.0230	0.560
Tube-8	0.0179	0.596
Tube-9	0.0150	0.640
Tube-10	0.0380	0.533
Tube-11	0.0314	0.594
Tube-12	0.0276	0.641
Tube-13	0.0341	0.572
Tube-14	0.0275	0.606
Tube-15	0.0236	0.650
Tube-16	0.0300	0.604
Tube-17	0.0235	0.628
Tube-18	0.0196	0.666

TABLE - 4 THE CONSTANT VALUES Ai AND Bi FOR THE DISTRIBUTION FACTORS EQUATION OF THE AVERAGE LATERAL LOADS

tube in tube system	Stiffness ratio Kw \ Kt	Constant Ai	Constant Bi
Tube-1	0.0290	10.546	-0.592
Tube-2	0.0241	10.599	-0.616
Tube-3	0.0211	9.130	-0.626
Tube-4	0.0260	10.414	-0.602
Tube-5	0.0215	9.850	-0.619
Tube-6	0.0181	8.638	-0.625
Tube-7	0.0230	9.185	-0.590
Tube-8	0.0179	9.888	-0.631
Tube-9	0.0150	8.046	-0.621
Tube-10	0.0380	6.733	-0.488
Tube-11	0.0314	6.432	-0.500
Tube-12	0.0276	5.650	-0.512
Tube-13	0.0341	6.447	-0.489
Tube-14	0.0275	6.185	-0.505
Tube-15	0.0236	5.544	-0.518
Tube-16	0.0300	4.902	-0.455
Tube-17	0.0235	5.599	-0.496
Tube-18	0.0196	4.839	-0.499

stiffness ratio (Kw/Kt) in Equ.(1), the values of N relative to each stiffness ratio (Kw/Kt) are presented in Table (3), and the average values of N can be obtained as (0.60) and Eqs.(1),(2) become:

$$Ww = Wt \, . (Kw/Kt)^{0.6} \qquad \ldots\ldots\ldots\ldots(3)$$

$$Wf = Wt \, .[1 - (Kw/Kt)^{0.6}] \qquad \ldots\ldots\ldots\ldots(4)$$

Because of the distribution of lateral loads through the height of each part of the tubular structure do not take the a constant value, the equation of the lateral load distribution must be corrected by a distribution factor (Df), the equation of the lateral load distribution has been taken the form;

$$Ww = Wt \, . \, Df \, . \, (Kw/Kt)^{0.6} \qquad \ldots\ldots\ldots\ldots(5)$$

$$Wf = Wt - Ww \qquad \ldots\ldots\ldots\ldots(6)$$

$$Df = Ai \, . \, (H)^{Bi} \qquad \ldots\ldots\ldots\ldots(7)$$

$$Ai = -2.60 \, Ln \, (Kw/Kt) - 1.85 \qquad \ldots\ldots\ldots\ldots(8)$$

$$Bi = 0.175 \, Ln \, (Kw/Kt) + 0.10 \qquad \ldots\ldots\ldots\ldots(9)$$

where;

Ai, Bi = the constant coefficients for the distribution factor (Df). see Table (4), H = the building height from ground level to the story at which the average lateral load required.

CONCLUSIONS

1- The shear wall inner tube greatly enhances the structural characteristics of the exterior framed tube by considerably reducing the shear displacement of the framed tube columns
2. For a uniform lateral load cases, the distribution of lateral loads between the inner tube (shear wall) and exterior framed tube is variable through the structure height.
3. The effect of the connecting shear wall beams on the total shear displacement of the tube in tube system are approximately small and it may be ignored.
4. The method is of a great importance to the designer as a simplified analysis of the tube in tube structural system under the uniform lateral load cases.

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