International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

The Thermal Response of Concrete Frame Buildings in Arabic Area Considering Time-Dependent Properties of Concrete

Ikhlass Sydnaoui, Roslli Bin Noor Mohamed, Mariyana Aida Binti Ab.Kadir

***Abstract:** The Arabic area is known for its significant changes in climate temperatures within different seasons. Riyadh, Cairo, Abu Dhabi, Ras Al-Khaimah, Kuwait, and Baghdad are subjected to the maximum variance in daily temperatures and presents the mean values of daily temperatures considering the data collected by the Hong Kong observatory in China for the last 30 years. The maximum mean value of daily temperature, which is 44.6 °C in Kuwait, and the minimum mean value of the daily temperature in Baghdad is 3.8 °C. The maximum difference values of daily temperatures are observed in the Arabic Gulf area countries, such as Abu Dhabi, Kuwait, and Riyadh. Hence, these values will be considered in this analysis. This study results fit the thermal requirements of Arabic area and regions with similar temperature variation, accounting for various design aspects considering both methodologies of time-dependent properties of concrete as per CEB FIP 90 code and non-time dependent properties as per ACI 224.3R. For those targets a finite element method is utilized by generating 272 single- storey concrete ETABS models. The models are categorized according to column support conditions and development of concrete properties over time. The study findings are utilized to develop a clear understanding of mentioned variable's effects at thermal deformations and column reactions to aid structural engineers in the thermal design of super-long buildings with similar conditions of this study within time. The thermal displacement grows in proportion to the height of the column and the length of the slab. The findings of the analysis also show that employing thick slabs slightly decreases thermal displacements for models with hinged column supports and a 6 m column height. The thermal reactions increase in proportion to the length of the slab and the fixity conditions. Meanwhile, these reactions are inversely proportional to the height of the column. The ratios of time-dependent deformation and reaction to those of non-time-dependent properties are within the range [159%-163%] and [168%-171%] respectively. Ignoring this difference imposes defects, additional cracks, and damages at the structures and related serviceability conditions for 70 years period.*

***Keywords:** Deformation, Non-Time Dependent Properties, Reaction, Time-Dependent Properties*

I. INTRODUCTION

In this paper, an analysis of the impact of daily changes in ambient temperature, shrinkage, and creep on reinforced concrete buildings considering both methodologies of evolution of concrete properties over time as defined according to the CEB-FIP (1999) code and non-time dependent properties as per ACI 224.3R.

The variation of thermal loads is based on the. Environment temperature fluctuation. Creep, and shrinkage are long-term phenomena. The CEB-FIP code proposes a series of equations for analysing the response of buildings over time. Given that the ETABS can analyse buildings affected by these complex phenomena, the CEB-FIP code equations have been incorporated into this program [8].

II. METHODOLOGY

A. Used methods

Two groups of three-dimensional finite elements Etabs models are generated. Both group models have the same geometrical properties with similar element sizes. The first group of ETABS models will be analyzed with time-dependent concrete properties for 70 years period considering the CEB-FIP 90 code method which is considered in the ETABS program while the second group of models will be analyzed with non-time dependent concrete properties with concrete strength of 40(N/mm²) hence this value is almost used for concrete buildings in Arabic area considering ACI 224.3R method. For each group two different support conditions will be considered, the fixed and the hinged columns support. Other variables will be considered in ETABS models such as two values for column height: 3 (m) and 6 (m). Slab length will be increased from 60(m) to 400(m) with 20(m) increments and two different slab thicknesses: 0.3 (m) and 0.4 (m) as a safe flat slab for punching and deflection. The annual thermal expansion coefficient value is approximately 1.852 of the correlated seasonal coefficients, and the correlated average value is 9.5×10^{-6}, as determined by various tests on unrestrained concrete samples with different reinforcement compositions, cement types, and aggregate sizes [2] and [3]. The concrete building under conditions of cooling and shrinkage is prone to cracking. As a result, premises built in the summer are more likely to suffer from tension cracking than those built in the winter, therefore, a reduction in temperature can be implemented using the finite element analysis method [5]

B. Defining thermal loads values for non-time dependent properties models

Two different methods are presented in ACI 224.3R. The first method is related to Martin and Acosta whereas. ΔT is the summation of the daily temperature changes and shrinkage,

Revised Manuscript Received on September 29, 2019.

* Correspondence Author

Ikhlass Sydnaoui*, Designer Structural Engineer, Faculty of Civil Engineering, University Teknologi Malaysia, Johor Bahru, Malaysia. E-mail: Ikhlass.sydnaoui@musanada.com

Dr. Roslli Bin Noor Mohamed, Faculty of Civil Engineering, University Teknologi Malaysia, Johor Bahru, Malaysia. E-mail: roslli@utm.my

Dr. Mariyana Aida Binti Ab. Kadir, Faculty of Civil Engineering, University Teknologi Malaysia, Johor Bahru, Malaysia. E-mail: mariyanaida@utm.my

$$\Delta T = \frac{2}{3}(Tmax - Tmin) + Ts \qquad (1)$$

whereas Ts is -17(C°)=-30(F°) for drying shrinkage consideration. The design temperature with maximum daily variation is 9-43=-34(C°) as shown in Fig. (1). while Ts is 17(C), the total variation will be

$\Delta T = \frac{2}{3}(Tmax - Tmin) + Ts$=22.6+17=39.7C°.

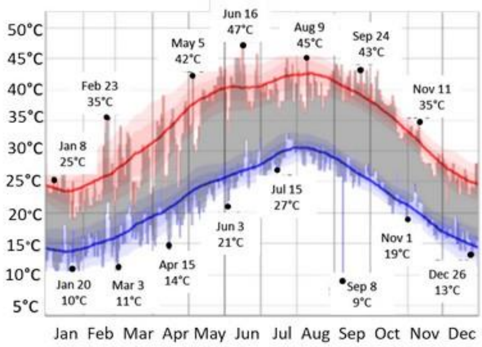

Fig. 1: Fluctuations in environmental temperature reported in 1997 (A.D.I.A, 2015) [6]and [7]

The 2nd method is related to the National Academy of Sciences ΔT is the largest from:

ΔT=Tw-Tm, or ΔT=Tm-Tc (2)

Where Tm is the temperature normally noticed within the construction period. Tw is the high temperature which is just exceeded for a ratio of one percent within the summer's or the low temperature exceeded ninety-nine percent within the winter season [1]. Historical weather for 1991 shows the highest difference in its daily temperature is noticed in January and June. The assumption of structure works begins in June at 47C°, the lowest temperature is in January with a Temperature of 6C°. Therefore, the difference is 47-6=41C°, 99%(41) =40C°

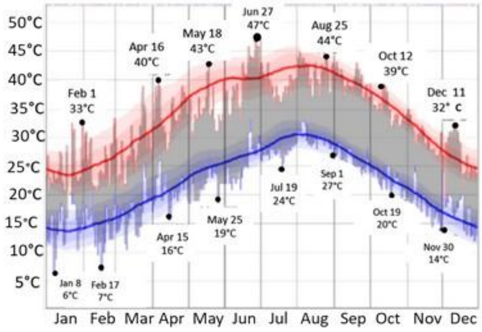

Fig. 2 Fluctuations in environmental temperature reported in 1991 [6] and [7].

The greatest temperature change is taken into account amongst both methodologies.

C. Defining thermal loads and concrete properties for time-dependent properties models

In non–time-dependent properties Etabs models, the maximum temperature variation was defined as follows, the maximum daily temperature was 43 °C, whereas the minimum was 9 °C. Consequently, the daily variance is 9-43=34 C. Shrinkage represents a slab contraction, thereby explaining the negative temperature difference. The required temperature variance according to Equation (1) is 2/3(34)+17=39 C. For time dependent analysis, the greatest difference in daily temperature (34 °C) was reported in September as the variance between 43 °C and 9 °C. Therefore, the environment temperature fluctuation is 2/3(34)=22.6 ˚C, as well as shrinkage effects of -17˚C.

, this temperature fluctuation -23C°is considered in time-dependent properties Etabs files in addition to creep and shrinkage loads to compare time-dependent properties with non-time dependent properties results. Etabs recognizes time-dependent properties of concrete as clarified in Fig. 3 below

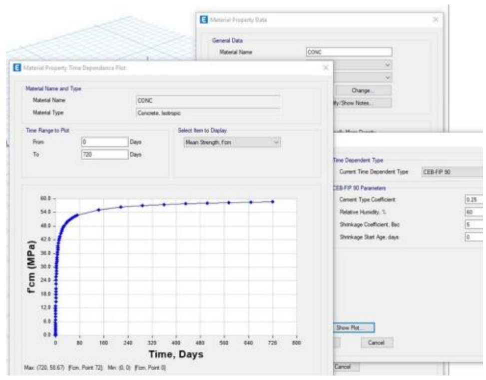

Fig. 3: Time-dependent concrete strength used in Etabs

The life span of the building is 70 years. The time-dependent type is CEB-FIP Model code-99. The relative humidity is 60% as the mean average value in the Arabic area, the national thickness is the thickness of the slab

III. RESULT AND DISCUSSION

A. Analysis of displacements considering non-time dependent properties of concrete

Fig. 4 shows the 3D view of a typical ETABS model.

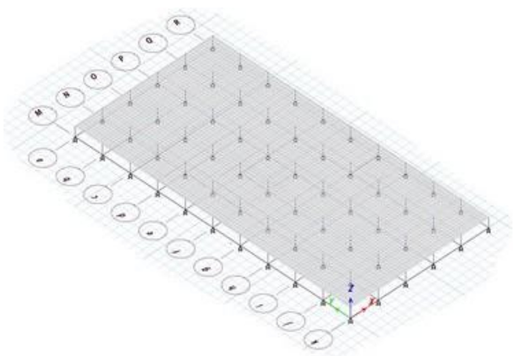

Fig. 4 The three-dimensional view from Etabs

While Fig. 5 shows the slab plan from ETABS model.

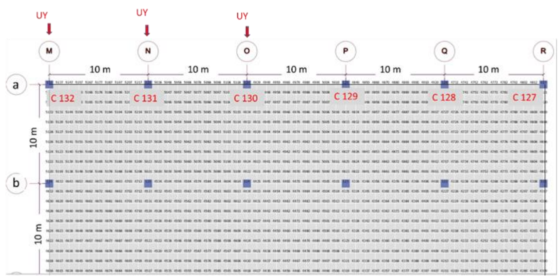

Fig. 5 the slab plan from Etabs model.

Retrieval Number: C6084098319/2019©BEIESP
DOI: 10.35940/ijrte.C6084.098319

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

A computer analysis is generated to determine the effects of thermal loads and shrinkage impact on finite element modelling of single storey concrete premises based on various design factors. The findings are displayed in Figure (6). It is obvious that maximum horizontal deformations UY values which are parallel to axis Y and length of the building are recognized at slab edges-axis (a) and (k) at internal columns C130/C129 and C131/C128 not the corner one. The thermal displacements (UY) rise along with the height of the columns and the length of the slabs. Thermal displacements decrease with increasing slab thickness for models with hinged supports due to increased building stiffness, while a slight increment is observed in the lateral deformations for models with 40 cm slab thickness and fixed column conditions compared with those for models with 30 cm slab thickness. Overall, all thermal displacements of single-storey models are smaller than those of unconstrained structures.

Upper curves indicate hinged models' displacements. The displacement curve of the fixed model with 6 m column height is close to that of hinged models with 3 m column height. Meanwhile, the results of fixed models with 3 m column height are significantly lower than those of others. The lower graph of deformations belongs to fixed column models with 3m column height.

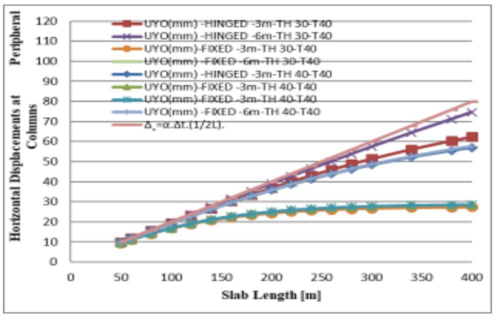

Fig. 6 Thermal displacements at external column (O OR 130)

Analysis of displacements considering time-dependent properties of concrete

Figures (7) and (8) show that the thermal displacements(UY) rise along with the height of the columns and the length of the slabs. Thermal displacements decrease with increasing slab thickness for models with hinged supports due to increased building stiffness while increasing slab thickness for fixed column conditions will increase the thermal deformations for super-long slabs. Both figures show that upper graphs are for hinged models' deformations with column height 6m with maximum displacement of (121mm/TH 30cm and 116.2 mm /TH 40cm). The graph of the fixed model's displacements with 6m column height is close to those of hinged models with 3m column height. While the results of fixed models with 3m columns height are significantly lower than others.

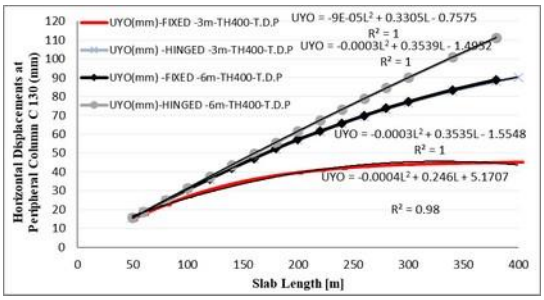

Fig. 7 Thermal displacements at external column (C130) for models with a 400 mm slab thickness

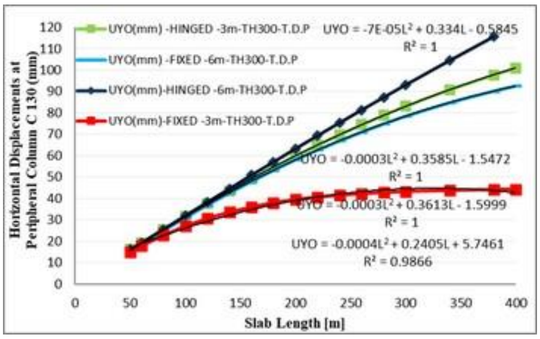

Fig. 8 Thermal displacements TDP at external column (C130) for models with a 300 mm slab thickness.

B. Analysis of reactions considering non-time dependent properties of concrete

An investigation of the influence of thermal changes in the Arab zone on the thermal reaction of the perimeter columns is carried out, the middle column at external slab edges at axis k and a. The results and correlated equations are presented in Figures (9) and (10). It is clear from both figures that models with thicker slabs have greater horizontal reactions. For instance, the reaction at the upper curve in Figure (9) is close to 4500KN for fixed models with 3m column height and 40cm slab thickness, while it reduced to 3500KN for similar models with 30cm slab thickness. The horizontal reactions rise along with slab length and fixity conditions. Meanwhile, these reactions are inversely proportional to the height of the column, consequently, the slab thickness factor seems with high importance at reaction results while its impact was minor at lateral thermal displacements values.

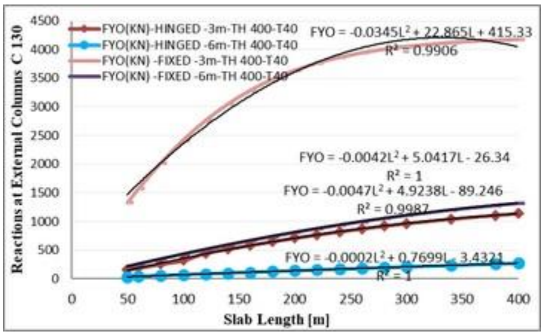

Fig. 9 Thermal reactions NTDP at external column (C130) for models with a 400 mm slab thickness

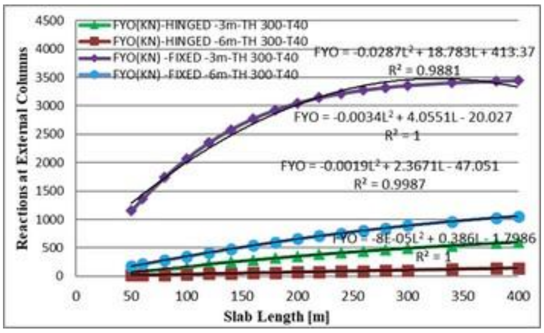

Fig. 10 Thermal reactions NTDP at external column (O) for models with a 300 mm slab thickness

C. Analysis of reactions considering time-dependent properties of concrete

Figures (11) and (12) display the horizontal reactions at the critical peripheral column with the biggest value of reaction, the middle column at external slab edges at axis k, and a. It shows that the horizontal reactions (FY) of fixed columns are greater than those of hinged columns, thereby suggesting that fixed column models require larger footings, columns and rebars than hinged one's under-considered thermal effects. Column height is inversely proportional to thermal reaction. The upper graph is related to concrete buildings with fixed support conditions and 3 m story height, they have the largest and most critical reactions exceeding 6000KN for super-long slabs. The horizontal reactions related to these ETABS models (7157KN /TH 40cm and 6100KN/TH 30cm) are also three times larger than those related to models with 6 m column height (2316KN/TH 40cm and 1848KN/TH 30cm). Moreover, the reactions of fixed column models with 50 m slab length and 3 m storey height (2233KN /TH 40cm and 1955KN/TH 30cm) are 8 to 15 times larger than those of hinged column models (268 KN/TH 40cm and 127.5KN/TH 30cm).

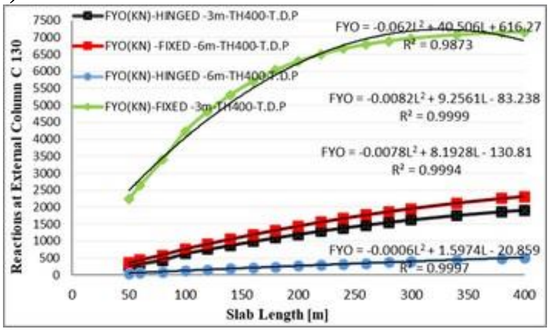

Fig. 11 Thermal reactions TDP at external column (C130) for models with a 400 mm slab thickness

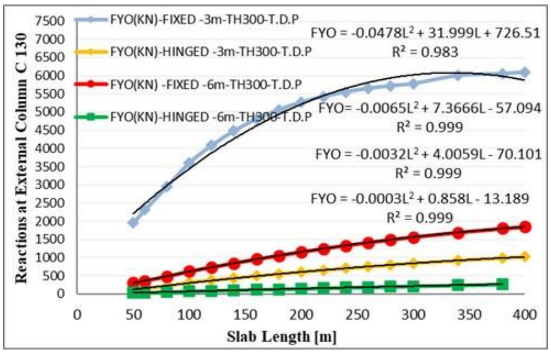

Fig. 12 Thermal reactions TDP at external column (C130) for models with a 300 mm slab thickness

D. Comparison of results between time-dependent and non-time dependent models:

Firstly, there will be a comparison between time-dependent properties (T.D.P) and non-time dependent properties (N.T.D.P.) models results regarding the imposed displacements at the structural system. Fig.s (13) and (14) clarifyt the horizontal displacements for the described buildings taking into account all previous variables These Figures show that time-dependent horizontal displacements are greater than those of NTDP models for all cases under all conditions with respect to the similarity in column height, slab thickness and support condition.

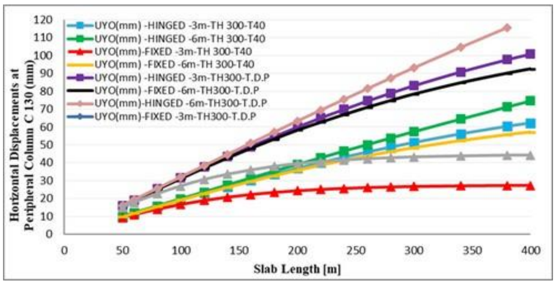

Fig. 13 Thermal displacements at external column (C130) for models with a 300 mm slab thickness.

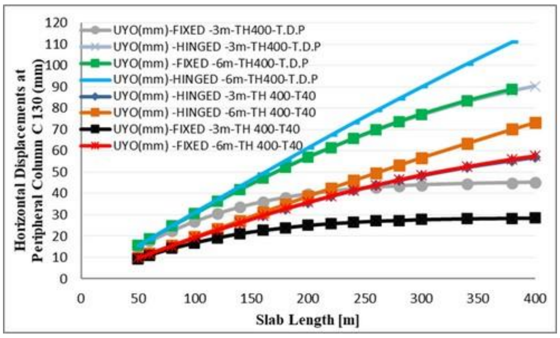

Fig. 14 Thermal displacements at external column (C130) for models with a 400 mm slab thickness

Table I presents the ratios of thermal displacements for CEB-FIP (1999) to ACI 224.3R code with minimum and maximum values of 158% and 163%, respectively. These additional deformations imposed by the time-dependent method exceed significantly those of the non-time dependent method. Ignoring the difference in these deformations can lead to defects in the structural elements and serviceability of buildings throughout their life span of 70 years due to excessive deformations at slab edges which affect brittle materials of the elevations in addition to the imposed cracks in slabs under tension stresses.

Table II Ratios of thermal displacements for CEB-FIP (1999) to ACI 224.3R code

Slab length. (m)	Slab thickness 30cm				Slab thickness 40cm			
	hinged		Fixed		Hinged		Fixed	
	Height 3m	Height 6m	Height 3m	Height. 6m	Height 3m	Height 6m	Height 3m	Height 6m
50	163%	163%	162%	162%	159%	159%	159%	159%
60	162%	163%	162%	162%	159%	159%	159%	158%
80	162%	162%	162%	162%	159%	159%	159%	159%
100	162%	162%	162%	162%	159%	159%	159%	159%
120	162%	162%	162%	163%	159%	159%	159%	159%
140	162%	162%	162%	162%	159%	159%	159%	159%
160	162%	162%	162%	162%	159%	159%	159%	159%
180	162%	162%	162%	163%	159%	159%	158%	159%
200	162%	162%	162%	163%	159%	159%	158%	159%
220	162%	162%	162%	162%	159%	159%	158%	159%
240	162%	162%	162%	162%	159%	159%	159%	159%
260	162%	162%	162%	162%	159%	159%	159%	159%
280	162%	162%	162%	162%	159%	159%	158%	159%
300	162%	162%	162%	162%	159%	159%	159%	159%
340	162%	162%	162%	162%	159%	159%	158%	159%
380	162%	162%	162%	162%	159%	159%	158%	159%
400	162%	162%	165%	162%	158%	159%	161%	159%
average	162%	162%	162%	162%	159%	159%	159%	159%

E. Comparison of reactions between T.D.P and N.T.D.P.

Figures 15 and 16 present the thermal reaction forces for all models taking into account both codes for concrete properties of CEB-FIP (1999) code and ACI 224.3R with all variables related to storey height and thickness of slabs as well as the support

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

conditions. These figures show that the reaction forces of TDP models are more than those of NTDP models with respect to the similarity in slab thickness, column heights and support conditions. The higher reactions at the upper graph are for fixed model conditions with height 3m and TDP of concrete with upper bound close to 6000KN. The lowest reactions are at the red curve for hinged model conditions with height 6m and NTDP of concrete with reaction forces lesser than 500KN.

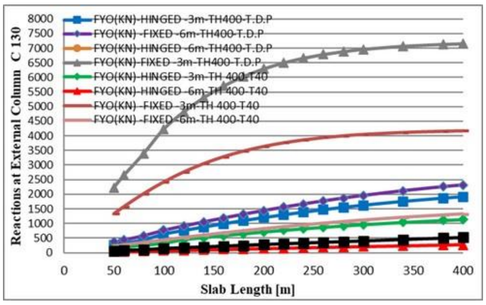

Fig. 15 Thermal reactions at external column (C130) for models with a 400 mm slab thickness

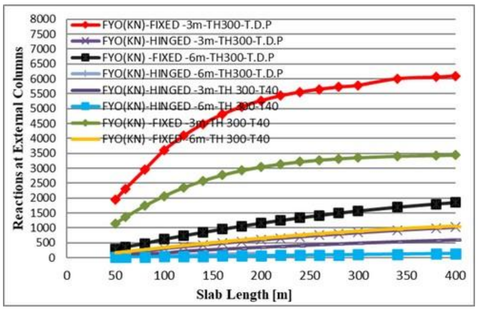

Fig. 16 Thermal reactions at external column (C130) for models with a 300 mm slab thickness

Table III displays the ratios of thermal reaction of both codes of CEB-FIP (1999) and ACI 224.3R methods.

The TDP models generally have higher thermal fluctuation and shrinkage reactions than the NTDP models with the minimum, maximum and mean ratios of 167%, 175% and 170%, respectively. This difference in reactions is major. The structural engineer must consider its effects on all columns, slabs and footings design. Additional thermal reactions require adequate steel bars within the mentioned structural members. The thermal forces at footings require adequate friction forces between the footings and the soil in addition to steel bars.

Table IV Ratios of thermal reactions for CEB-FIP (1999) to ACI 224.3R code

Slab. length (m)	Slab thickness 30 cm.				Slab thickness 40cm			
	hinged		fixed		hinged		fixed	
	Column height (3m)	Column height (6m)	Column height (3m)	Column height. (6m)	Column height (3m)	Column height (6m)	Column height (3m)	Column height (6m)
50	171%	171%	170%	170%	168%	169%	168%	168%
60	171%	171%	170%	170%	168%	168%	168%	167%
80	171%	171%	170%	170%	168%	169%	167%	167%
100	171%	171%	174%	177%	196%	192%	174%	177%
120	171%	171%	170%	170%	168%	168%	168%	168%
140	171%	171%	170%	170%	168%	168%	167%	168%
160	171%	171%	170%	170%	168%	168%	167%	168%
180	171%	171%	170%	170%	168%	168%	167%	168%
200	171%	171%	170%	170%	168%	168%	167%	168%
220	171%	171%	170%	170%	168%	168%	167%	168%
240	171%	171%	170%	170%	168%	168%	167%	168%
260	171%	171%	170%	170%	168%	168%	167%	168%
280	171%	171%	170%	170%	168%	168%	167%	168%
300	171%	171%	170%	170%	168%	168%	167%	168%
340	171%	171%	174%	170%	168%	168%	167%	167%
380	171%	171%	174%	170%	168%	168%	167%	167%
400	171%	171%	175%	170%	168%	168%	167%	167%
average	171%	171%	171%	170%	170%	170%	168%	168%

The following analysis aims to define the evolution of thermal displacements over different periods such as two years, ten years, thirty years, sixty years, and the whole life span of 70 years for the structure.

Table VI shows the thermal displacements for models with slab thicknesses of 300 mm as well as 6m and 3 m storey height over two years, ten years, thirty years, sixty years, and seventy years. Table V shows the corresponding thermal displacements for models with a slab thickness of 400 mm.

Table IV thermal displacements for CEB-FIP (1999) over time

Slab length. (m)	Height of column (3 m)					Height of column (6 m)				
	2 year	10 year	30 year	60 year	70 year	2 year	10 year	30 year	60 year	70 year
50	9.7	12.8	14.4	15.0	15.1	10.2	13.6	15.2	15.8	15.9
60	11.4	15..1	17.0	17.7	17.8	12.3	16.2	18.2	18.9	19.0
80	14.6	19.3	21.7	22.6	22.7	16.2	21.5	24.1	25.1	25.2
100	9.8	23.0	25.8	26.8	27.0	20.1	26.6	29.8	31.0	31.2
120	19.7	26	29.2	30.4	30.6	23.2	31.6	35.2	36.8	37.1
140	21.6	28.6	32.1	33.3	33.5	27.5	36.4	40.8	42.4	42.7
160	23.1	30.6	34.3	35.7	35.9	31	41.0	46.2	47.8	48.1
180	24.3	32.2	36.2	37.6	37.9	34.3	45.4	51.0	53.0	53.3
200	25.3	33.5	37.6	39.1	39.4	37.5	49.6	55.7	57.9	58.3

Table V: Horizontal displacements (in mm) over different periods

Slab length. (m)	Height of column (3 m)					Height of column (6 m)				
	2 Year	10 year	30 year	**60 years**	70 years	2 year	10 year	30 year	60 year	70 year
50	8.9	11.9	13.9	14.7	14.9	9.3	12.5	14.5	5.8	15.6
60	10.5	14.1	16.4	17.4	17.6	11.1	14.9	17.4	18.5	18.6
80	13.4	18.0	21.0	22.3	22.5	14.7	19.8	23.0	24.5	24.7
100	16.0	21.5	21.5	26.6	26.9	18.2	24.5	28.6	30.3	30.6
120	18.2	24.4	28.5	30.2	30.5	21.7	29.1	33.9	36.0	36.3
140	20.0	26.9	31.3	33.2	33.6	25.0	33.5	39.1	41.5	41.9
160	21.5	28.9	33.7	35.7	36.1	28.1	37.8	44.1	46.8	47.2
180	22.7	30.5	35.6	37.7	38.1	31.2	41.9	48.9	51.8	52.3
200	23.7	31.8	37.1	39.4	39.7	34.1	45.8	53.4	56.7	57.2

The lateral displacements per CEB-FIP99 method models over two years are roughly close to those of ACI models, with a ratio ranging from 0.95 for models with 400 mm slab thickness to 1.04 for models with 300 mm slab thickness, whereas for thirty years it ranges from 1.48 to 1.55, then for sixty years it varies from 1.57 to 1.61affecting the location of expansion joints. The development of thermal displacement over time is obvious, so the thermal displacement of two years is almost 0.65 of imposed displacement over seventy years, then this ratio increases to 0.83 over ten years, which is a high ratio of total expected deformation within 70 years, and the rise in this ratio develops over 30 years and 60 years to reach 0.93 and 0.99 of expected deformation within 70 years, respectively. As a result, 0.65 percent of shrinkage displacements are released within the first two years of building life, nearly 83 percent are released within the first ten years, and shrinkage effects appear to increase slowly during the remaining years of building life. These differences, specifically, can increase the imposed thermal forces and stresses within slabs and columns, thereby expanding the areas requiring additional thermal rebars. Tables VI and VII show the increment in the ratio of stresses per CEB-FIP 99 over all periods versus those of NTDP PER ACI 224.3R for analyzed models based on column heights of six meters

Table VI Ratios of thermal stresses for CEB-FIP (1999) to ACI 224.3R code for hinged buildings

Slab length (m)	Hinged columns conditions									
	Slab thickness (300 mm)					Slab thickness (400 mm)				
	2years /NTDP	10 years /NTDP	**30years /NTDP**	**6**0 years /NTDP	70 years /NTDP	**2**years /NTDP	10 years /NTDP	**30years /NTDP**	**6**0 years /NTDP	70 years /NTDP
50	1.25	1.56	1.70	1.83	1.86	1.13	1.44	1.66	1.78	1.83
60	1.23	1.54	1.68	1.81	1.83	1.11	1.42	1.64	1.76	1.80
80	1.21	1.51	1.65	1.77	1.80	1.04	1.32	1.53	1.64	1.68
100	1.25	1.56	1.64	1.76	1.86	1.08	1.38	1.59	1.71	1.72
120	1.19	1.48	1.62	1.74	1.77	1.04	1.32	1.53	1.64	1.68
140	1.15	1.43	1.56	1.68	1.68	1.04	1.32	1.53	1.64	1.68
160	1.18	1.47	1.61	1.73	1.76	1.06	1.36	1.56	1.68	1.73
180	1.18	1.47	1.61	1.73	1.75	1.06	1.35	1.56	1.68	1.72
200	1.15	1.46	1.60	1.72	1.75	1.04	1.32	1.53	1.64	1.68

Table VII Ratios of thermal stresses for CEB-FIP (1999) to ACI 224.3R code for fixed buildings

Slab length (m)	Fixed columns conditions									
	Slab thickness (300 mm)					Slab thickness (400 mm)				
	2years /NTDP	10 years /NTDP	30years /NTDP	60 years /NTDP	70 years /NTDP	2years /NTDP	10 years /NTDP	30years /NTDP	60 years /NTDP	70 years /NTDP
50	1.15	1.44	1.57	1.69	1.71	1.04	1.32	1.40	1.51	1.68
60	1.15	1.44	1.57	1.69	1.71	1.11	1.42	1.64	1.76	1.80
80	1.15	1.44	1.57	1.69	1.71	1.04	1.32	1.53	1.64	1.68
100	1.15	1.44	1.57	1.69	1.71	1.04	1.32	1.53	1.64	1.68
120	1.15	1.44	1.57	1.69	1.71	1.08	1.37	1.58	1.70	1.74
140	1.15	1.44	1.57	1.69	1.71	1.07	1.36	1.57	1.69	1.74
160	1.06	1.33	1.45	1.56	1.58	1.09	1.32	1.57	1.69	1.73
180	1.15	1.44	1.57	1.69	1.71	1.06	1.35	1.56	1.68	1.72
200	1.17	1.47	1.60	1.72	1.75	1.06	1.35	1.56	1.68	1.72

Tension stresses are significantly higher CEB FIP 99 analysis than ACI 224.3R. This variation has a significant impact on the thermal design of structural elements such as slabs and rebars, which are installed to withstand additional thermal stresses throughout the entire life span of the building. The ratio of thermal stresses per CEB-FIP99 for two years versus ACI method models of concrete ranges from 1.06 to 1.25, while it ranges from 1.32 to 1.56 for ten years. The correlated ratio of thermal stresses for thirty years varies from 1.44 to 1.66, this ratio develops for sixty years ranging from 1.51 to 1.78. The values recorded over two years are very close to those captured by the ACI 224.3R process.

IV. CONCLUSION

The effect of support condition, column height and slab thickness on the thermal response of reinforced concrete buildings based on TDP of concrete is essential. Given that an increment in slab thickness reduces the horizontal deformations, axial stiffness is directly proportional to slab thickness and area. In this case, thicker slabs have higher stiffness with lower thermal deformations and higher reactions. The deformations of models with hinged column support conditions are greater than those of models with fixed column support conditions. Increasing column height reduces significantly the forces and stresses due to reducing the column stiffness. However, the thermal response of super-long reinforced concrete buildings considering time-dependent properties of concrete is more than those for non-time dependent properties of concrete for all analyzed cases. This variance increases with time throughout the life span of the building. Such variance also imposes additional strains, forces and stresses. As a result The development of thermal displacement over time is obvious, so the thermal displacement of two years is almost 0.65 of imposed displacement over seventy years, then this ratio increases to 0.83 over ten years, which is a high ratio of total expected deformation within 70 years, and the rise in this ratio develops over 30 years and 60 years to reach 0.93 and 0.99 of expected deformation within 70 years, respectively. As a result, 0.65 percent of shrinkage displacements are released within the first two years of building life, nearly 83 percent are released within the first ten years, and shrinkage effects appear to increase slowly during the remaining years of building life. These differences, specifically, can increase the imposed thermal forces and stresses within slabs and columns, thereby expanding the areas requiring additional thermal rebars. The thermal stresses of all analysed models exceed the tensile capacity of concrete in all periods of 2, 10, 30, 60, and 70 years increased over time, so thermal reinforcement was required.

The imposed stresses over the seventy years are approximately 145 percent of the released stresses during the first two years of building life. The average figure for imposed stresses during the first ten years of a building's life is 84 percent, meaning the building has released most of the thermal stress during its first 10 years of operation but will endure additional stress in the following years. The results of this study highlight the importance of analyzing such phenomena and their effects whilst taking the entire life span of the building.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support of this research by UTM, Faculty of Civil Engineering UTM.

REFERENCES

1. ACI Committee 224.3R, "Joints in concrete construction," pp. 1-43, 2001.
2. Havel , A. Anthony,S.and Archilla, R. (2015). 'Coefficient of Thermal Expansion of Concrete Mixes in Hawaii: Determination and Implications for Concrete Pavement', Design. Journal of Materials in Civil Engineering, 27, pp 56-78.
3. Abid, S., Mussa, F., Tayşi, N., and Özakça, M. (2018). 'Experimental and finite element investigation of temperature distributions in concrete-encased steel girders', Structural Control and Health Monitoring, 25, pp 1–23.
4. Cho, P. Park, D. Kim, J. and Hamasaki, H. (2017). 'Study on the heat-moisture transfer in concrete under the real environment', Construction and Building Materials, 132, pp 124-129.
5. Badrah, M., and Jadid, N. (2013). 'Investigation of developed thermal forces in long concrete frame structures', benthamscience.net. Open Civil Engineering Journal, 3(7), pp 210-217.
6. Daily temperature, " https://weatherspark.com/history.
7. Worldmeteorlogicalrganization, http://www.worldweather
8. Ahmed, K. (2011). 'Temperature Effects in Multistory Building', Journal of Engineering Sciences, Assiut University, 39, pp 249-267.

AUTHORS PROFILE

Ikhlass Sydnaoui: Preparing for PHD degree at UTM university in structural –civil engineering, final viva is at 2020
Master's Degree in structural – building Engineering, (Structure Section), Alhosn University2015, GPA 3.97/4
Preparing for Master's Degree in Civil Engineering, (Structure Section), Damascus University
High diploma (2 years with 10 structural subjects and thesis) in structural engineering design, Damascus University, 82% (2001)
Bachelor's Degree in Structural/ civil Engineering, (structure Section), Damascus University, (1999)
20 years experience as a structural design engineer and then senior structural reviewer and designer
5 years as a lecturer in Damascus university for civil engineering college
A competent result-driven senior structural engineering professional with 20 years of experience, including 15 years of international experience in the UAE in the Middle East, mainly in areas of managing, reviewing & structural designing engineering for many projects constructed as per recognized American codes, British standards and local authority's requirements.

Dr. Roslli Bin Noor Mohamed |
Right alert (DS52)
Second Vice-Chair of the School Chair
Faculty of Engineering
School of Civil Engineering
Department of Structure & Materials Faculty of Civil Engineering University of Technology Malaysia Skudai
roslli@utm.my roslli@utm.my
Academic coordinator at post graduate (course work) with continuous following up with post graduate students
Senior Lecturer, Universiti Teknologi Malaysia

With different conferences and publications such as:

The performance of pretensioned prestressed concrete beams made with lightweight concrete
W Omar, RN Mohamed
Malaysian Journal of Civil Engineering 14 (1)

Shear strength of short recess precast dapped end beams made of steel fibre self-compacting concrete
RN Mohamed, KS Elliott
33rd Conference on Our World in Concrete & Structures, Singapore Concrete …

The effects of inclined shear reinforcement in reinforced concrete beam
NF Zamri, RN Mohamed, NHA Khalid, KY Chiat
Malaysian Journal of Civil Engineering 30 (1)

Dr. Mariyana Aida Ab Kadir is a Senior Lecturer at the Structure and Materials Department, Faculty of Civil Engineering, Universiti Teknologi Malaysia (UTM). She is the Research Fellow at the Institute of Noise and Vibration (INV) and Engineering Seismology and Earthquake Engineering Research (eSEER). After completing her secondary education at Mara Junior Science College, she pursues her B.Eng in Civil Engineering at UTM with First Class Honours and Chancellor's Award in 2005. She was awarded Erasmus Mundus Scholarship for M.Sc in Earthquake Engineering and Seismology Engineering at two universities; University of Pavia, Italy and Université Joseph Fourier, Grenoble France before completing a PhD at the University of Edinburgh, Scotland United Kingdom in Structural Seismic and Fire Engineering. Dr. Mariyana's research interest focuses on the vulnerability of structures exposed to the risk of hazards for earthquake and fire, soil-structure interaction, input ground motion for structural design, new structural system for earthquake and fire, and durability of concrete materials. She particularly focuses on the earthquake and fire performance of the concrete structure.