Jurnal Kejuruteraan 34(3) 2022: 375-385
https://doi.org/10.17576/jkukm-2022-34(3)-04

A Review Study on Theoretical Comparison Between Time-Dependent Analysis Models for Prestressed Concrete Bridges

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Received 13 November 2021, Received in revised form 23 December 2021
Accepted 23 January 2022, Available online 30 May 2022

ABSTRACT

Particularly, concrete material involvements creep under a continuous load and practices shrinkage due to variations in humidity proportion. These physical properties variations growth over time. Prestressed losses according to concrete creep and shrinkage will lead to loss of compression strength for concrete. Time-dependent analysis is important and essential for two types of prestressed concrete which are pretensioned and posttensioned with the effect of time, variations in the structural pattern, and high erection loads influence the structural performance and protection of structure for the duration of erection and when complete. Creep and shrinkage are the main time-dependent parameters of concrete. They are important parameters in the design of prestressed concrete structures such as bridges. The objective of this study is to review the analysis models of time-dependent parameters for prestressed concrete bridges by using shrinkage and creep factors equations to determine the strain of time-dependent parameters. Creep and shrinkage parameters were selected to review the effect of these parameters on the properties of prestressed concrete. Nine analysis methods for creep and shrinkage of concrete were reviewed in this study. These models include ACI-209 model, PCI-BDM model, CEB-FIP-90 model, AASHTO-LRDF model, Shams and Kahan model, NCHRP-496 model, B3 model, GL2000 model, and AFREM model. It was recommended that using this methodology to determine shrinkage and creep factors for prestresssed concrete bridge and comparing between the results of analysis models.

Keywords: Time-dependent; model; creep; shrinkage; moisture; prestressed concrete

INTRODUCTION

Structure of bridge is usually used in lifelines. Bridge has an important location in the financial activities of capitals and cities of countries. It is one of the significant parts of any transportation highway and railway networks. It is weighty civil structure which erected to span over numerous barriers such as waterway, valleys, road and rail network. This structure offers critical assembly between different structural members of transportation else un-joinable. Normally, all types of bridges comprise of two structural components such as superstructure and substructure. Structurally, the bridge superstructure involves all associates of the bridge structure upper the substructure. The important parts of the bridge superstructure contain on the pavement layer, the concrete deck, and different types of beams or girders. The duty of the superstructure is assembly the dissimilar kinds of loads then transmission these loads to the substructure of bridge. The substructure takes achievements as a foundation of the bridge. It consists of the retaining walls, abutments, piers, piers cap, bearings, and stands (Ali et al. 2021; Ali 2021; Ali F. 2021; Ali F. N. 2021; Naser & Zonglin 2011; Ali, 2018; WSDT 2010; Mohan 2017; Hussam & Ali 2020; Naser A. 2017; Ali 2018).

The prestressing methods are applied of the preloading of a structure before the subjected to the service loads. Generally, there are two kinds of prestressing which are known as pretensioning and posttensioning. They are strengthening methods of concrete structures with high strength steel strand (tendons). Normally, prestressing technique designates to determine carrying a self-equilibrated state of stresses in concrete structures before they are subjected to different types of loads. By using prestressed system, it is a significant to recover structural performance of concrete structure such as strength, elasticity, stiffness, and restraint of cracks by decreasing of tension stresses. Prestressing can be used in recovery of structural performance, strengthening of structures by offering restraining load. Prestressed concrete bridges frequently subjected to the natural environment are susceptible to cracking. Under prestressing forces, the cracks may be eliminated and reduced, but they will develop under high traffic loads (Ali & Zonglin 2010; Gasparini 2006; PCI 1968; Arthur 1987; Weiwei & Teruhik 2017; Naresh 2012; Chunyu 2016; Hewson 2003).

Concrete is a time-dependent material. Particularly, concrete material involvements creep due to a continuous load and practices shrinkage due to variations in humidity ratio. Physical variations growth with time. Prestressed losses according to concrete creep and shrinkage will lead to loss of compressive load for concrete (Wonchang 2006).

Time-dependent analysis is important and essential for two types of prestressed concrete (pretensioned and posttensioned) with the effect of time, variations in the structural pattern, and high erection loads influence the structural performance and protection of structure for the duration of erection and when complete. In several cases, the needing for time-dependent analysis is encouraged by severe distortion necessity or an unfamiliar structural geometry such as curved and uninform sections. The main model of the type of erection needing time-dependent analysis is the stable cantilever bridge. In this method, the moments can be calculated for the duration of the erection stage are bigger above the supports then the resultant moments in the ends of bridge. Time-dependent has different influences on the structural behavior from one statically system to another. It is meaning that, for determinate structure, creep and shrinkage product in rearrangement of strains and stresses inside individual sections, causing a reduction in the compression in concrete and tension in steel reinforcement (Aalami, 1998; Kahn et al. 1997; Ahmed 1997; Wonchang 2006; Adrian 1971; Westerberg 2008).

Creep and shrinkage are the main time-dependent parameters of concrete. They are important parameters in the design of prestressed concrete structures such as bridges. Directly, creep and shrinkage influence the properties variations of concrete in length over time. They are affected by features of concrete, exposure situations air and erection steps, which are in sequence for prestressed concrete structures. They influence encourage further internal forces and defections to the structure. In actual fact, shrinkage of concrete is because of water evaporating from concrete and hydration of its elements with time. Meanwhile creep is one of the furthermost significant time-dependent factors of concrete which causing to increases the cracks and damages the function, durability, and structural presences (Oliva & Cramer 2008; Denis 2002; Dinkha & Yousif 2021; Cluley & Shephened 1996).

Generally, time-dependent non-linear parameters involve creep strain which is the time-dependent variation in the strain below continuous load, the shrinkage is the time-dependent variation in strain below constant temperature, relaxation which is the losses of prestressed parts when they are subjected to constant strain, and aging which is denote to concrete ages. The overall strain in a un-axially overloaded concrete sample can be determined by the collecting of elastic strain, creep strain, shrinkage strain, and thermal strain (Hari, 2003)

$$\varepsilon(t) = \varepsilon_E(t) + \varepsilon_c(t) + \varepsilon_{sh}(t) + \varepsilon_T(t) \tag{1}$$

Where: $\varepsilon(t)$= overall strain, $\varepsilon_E(t)$= elastic strain, $\varepsilon_c(t)$= creep strain, $\varepsilon_{sh}(t)$= shrinkage strain, and $\varepsilon_T(t)$= thermal strain

The objective of this paper is to review the analysis models of time-dependent parameters to determine the creep and shrinkage strains for the prestressed concrete bridge by using shrinkage and creep factors equations.

TIME-DEPENDENT PARAMETERS

TYPES OF CONCRETE SHRINKAGE

Shrinkage of concrete is unavoidable under ordinary conditions unless are used a special kind of cement for the erection. Non-shrink concrete can be produced by using the cement which has not volume decreasing after pouring. This represents the only solution for this situation. Shrinkage of concrete can be categorized into different kinds according to the loss kind of pore moisture which it leads to occur shrinkage. Figure 1 shows the kinds of shrinkage and Figure 2 shows the shrinkage curve of concrete. (Hari 2003; Maher et al. 2003; Huang et al. 2015; Prasad; Merima et al. 2012; Larosche 2009; House Design 2021; Viktor et al. 2008).

PLASTIC SHRINKAGE

Within plastic stage, shrinkage in concrete is resultant due to the loss of water from the hardening concrete surface. It is exposed to severe environmental situations such as high speed of wind, higher temperature, and low qualified humidity. All these factors can be caused to loss the water from the pores and they will lead to occur plastic shrinkage.

AUTOGENOUSLY SHRINKAGE

This type of shrinkage can be occurred due to the ingesting of pore water by hydration response. In general, shrinkage of concrete is produced due to movement of moisture in or out of concrete. Shrinkage happens according to the results of inner moisture movements, when this movement of moisture is not allowable. In hydration procedure, water in the new shaped voids responds with cementations materials, creating a bulk past of minor volume than the combined volume of water and cementations materials previous to hydration.

DRYING SHRINKAGE

Directly after curing is completed, concrete activates to shrink at a comparatively high amount. Experience of concrete to an environmental with lower qualified humidity and comparing with the humidity in the concrete passageway link will result in the imbalance in the qualified humidity between the concrete and environment, leading to a loss of water from the concrete to the environment. This results to occur the dry shrinkage of concrete.

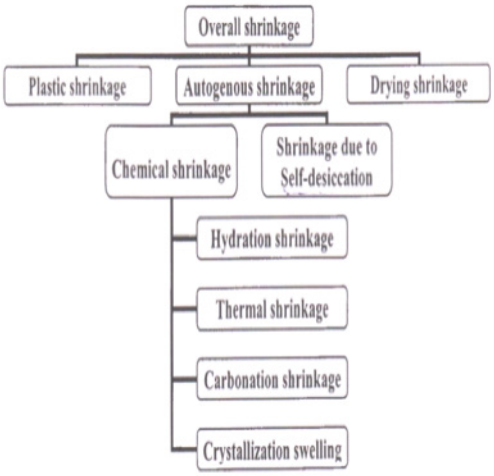

FIGURE. 1 The Types of Shrinkage (Maher et al. 2003)

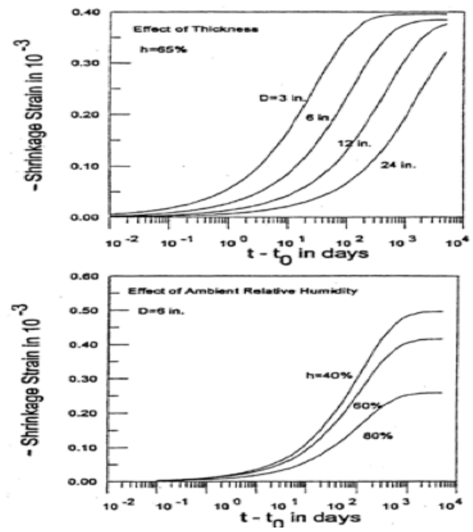

FIGURE. 2 Shrinkage of concrete

CREEP OF CONCRETE

creep of concrete has important effects in the design life and structural performance of concrete structures. It denotes to the deformation of structure under continuous load. Essentially, when concrete structure is subjected to higher loads and stresses for long time, partially or totally will lead to change in shape of structure and dimensions (deformation). This deformation typically happens in the direction the force which is applied on structure such as concrete column receiving more compressed or a beam subjected for bending. Unavoidably, creep of concrete does not lead concrete to fail or breakdown. Creep is an important parameter in the design of concrete structures. The influences of creep in reinforcement concrete parts can be caused an important variation in the internal stresses. Creep of concrete create the greatest important time-dependent influence on prestress losses. The degree and amount of creep depends on time the concrete state when it subjected to load at first time, the stress amount, the qualified moisture, curing situations, and the concrete mix, fine and coarse aggregates features, and amount of water/cement ratio. Figure 3 shows the creep deformation. (Mingfang et al. 2020; Gambali & Shanagam 2004; Christopher 2004; Hashim 1986; Bazant 2001; Folker 2015).

The surface roughness of the aggregate has a significant influence on occurring of creep for the reason that aggregate adhesive boundary effects the aggregates capacity for resistance of bend. According to cement adhesive creeps, loads are transported additional professionally to aggregates with a coarser apparent. Consequently, coarser apparent of aggregates have a propensity to decrease the creep strain (Mokhtarzadeh & French 2000; BaZant & Wittmann 1982).

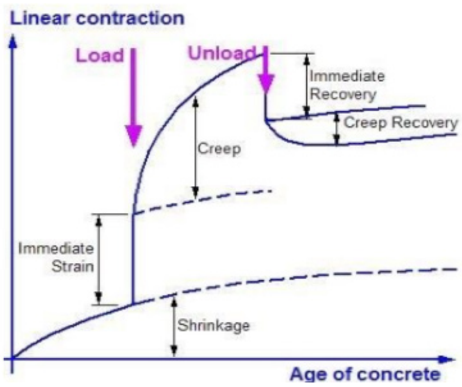

FIGURE. 3 The creep deformation (Gambali and Shanagam 2004)

The ratio of water/cement (w/c) in the concrete mix has important effects on the creep, meaning that lesser water-to-cement ratio will decrease the volume of the hydrates and also decrease the free water in the concrete. Both of these features have the effect of decreasing creep strain (Neville 1970)

THEORETICAL ANALYSIS OF CREEP FACTOR AND SHRINKAGE STRAIN

The calculation of the time-dependent parameters of prestressed concrete bridge is based on the recommendations of many methods. These parameters include the modulus of elasticity, creep coefficient, and shrinkage strain (ACI Committee 209.2R-08, 2008).

ACI-209R-92 MODEL

ACI Committee-209 offers approvals for calculation of creep factor, shrinkage strain, and overall strain. The overall strain at constant temperature is given by: [ACI Committee 209-92, 1997, Brian D. Swartz, 2010]

$$\varepsilon(t) = (\varepsilon_{sh})_t + \frac{\sigma}{E_o}(1 + V_t) \qquad (2)$$

Where:
σ= applied stress, E_o= concrete modulus of elastic.

The creep factor for a loading stage which is equal to 7 days for humid dried concrete or 1-3 days for vapor dried concrete is determined by using:

$$V_t = \frac{t^{0.6}}{10 + t^{0.6}} V_u \quad (3)$$

Where:
V_t= creep factor within time (t), V_u= critical creep factor calculated by:

$$V_u = 2.35\gamma_c \quad (4)$$

Where:

The shrinkage strain after 1-3 days for steam cured concrete is determined by:

$$(\varepsilon_{sh})_t = \frac{t}{55 + t} (\varepsilon_{sh})_u \quad (5)$$

Where:
$(\varepsilon_{sh})_t$= shrinkage strain within time (t), $(\varepsilon_{sh})_u$= critical shrinkage strain calculated by:

$$(\varepsilon_{sh})_u = 780\gamma_{sh} \times 10^{-6} \quad (6)$$

Where:
γ_{sh} = produce of the improvement parameters for qualified moisture (γ_λ), dimension (γ_{vs}), and concrete arrangement containing collapse (γ_s), fine aggregate proportion (γ_ψ), cement contented (γc), and air contented ($\gamma\alpha$).
For creep:

$$\gamma_\lambda = 1.27 - 0.0067\lambda$$

$$\gamma_{vs} = \frac{2}{3}(1 + 1.13e^{-0.54v/s}$$

$$\gamma_s = 0.82 + 0.067s$$

$$\gamma_\psi = 0.88 + 0.0024\psi$$

$$\gamma_\alpha = 0.46 + 0.09\alpha \geq 1.0$$

For shrinkage:

$$\gamma_\lambda = 1.40 - 0.017\lambda \quad \text{for} \quad 40 \leq \lambda \leq 80$$

$$\gamma_\lambda = 3.0 - 0.030\lambda \quad \text{for} \quad 40 \prec \lambda \leq 80$$

$$\gamma_{vs} = 1.2e^{-0.12v/s}$$

$$\gamma_s = 0.89 + 0.041s$$

BRIDGE DESIGN MANUAL (PCI-BDM) MODEL

The PCI-BDM offers two approaches to determine creep factor and shrinkage straining. Firstly, the approach depends on approvals of ACI-209, 1992 and it is appropriated to concrete compressive strength extending between 3ksi and 5ksi. Secondly, the approach depends on adjustments to the approvals of ACI-209 by Huo, 1997, and is applied for concrete compressive strength extending between 4ksi and 12ksi (PCI, 1997).

On behalf of concrete strength extending between 3ksi and 5ksi, the creep factor is calculated according to following equation:

$$C(t, t_o) = \frac{(t - t_o)^{0.6}}{10 + (t - t_o)^{0.6}} C_u \quad (7)$$

$$C_u = 1.88K_c \quad (8)$$

Where:
K_c= creation of improvement parameters for loading stage (k_{la}), average qualified moisture (k_h), dimension of the structural part (k_s).

On behalf of concrete compressive strengths extending between 4ksi and 12ksi, the creep factor is calculated according to following equation:

$$C(t, t_o) = \frac{(t - t_o)^{0.6}}{(12 - 0.5f`_c) + (t - t_o)^{0.6}} K_{st} C_u \quad (9)$$

$$K_{st} = 1.18 - 0.045f`_c \quad (10)$$

Where:
$f`_c$= concrete compressive strength (ksi) within 28 day,
K_{st}= improvement parameter for concrete strength.

After one to three days of vapor drying, shrinkage straining of concrete strength extending between 3 ksi and 5 ksi can be calculated according to following equation:

$$S(t,t_o)=\frac{(t-t_o)}{55+(t-t_o)}Su \qquad (11)$$

$$S_u=545K_{sh}\times10^{-6} \qquad (12)$$

Where:
K_{sh} = produce of improvement parameters of average qualified moisture (k_h) and dimensions of the structural partmember (k_s).

On behalf of concrete strengths extending between 4ksi and12 ksi, shrinkage strain can be determined according to following equation:

$$S(t,t_o)=\frac{(t-t_o)}{(65-2.5f^{`}{}_c)+(t-t_o)}K_{st}Su \qquad (13)$$

$$K_{st}=1.2-0.05f^{`}{}_c \qquad (14)$$

CEB-FIP-90 MODEL

The recommendations of CEB-FIP, 1993 model code are applied on concretes which have compression strength extending between 1.7ksi and 11.6ksi and they are exposed to compression stresses lower than 40% of the strength at using of load and they are unprotected to an middling qualified moisture extended between 40 % and 100% for temperature extending between 5Co to 30Co. The determined creep factor (φo) and shrinkage straining (ε_{cso}) are founded from concrete characteristics before application of load on suitable time proportion to find the creep factor, φ(t, to), and shrinkage straining. The overall strain is calculated by: (CEB, 1993)

$$\varepsilon(t)=\varepsilon_{cs}(t,t_o)+\sigma\left[\frac{\phi(t,t_o)}{E_c}+\frac{1}{E_c(t_o)}\right] \qquad (15)$$

$$E_c=3117500\left[\frac{f_{cm}}{1450}\right]^{1/3} \qquad (16)$$

Where:
$E_c(t_o)$= concrete elasticity modulus within time of applied load (psi), f_{cm} = concrete compressive strength (psi).

The creep factor can be determined by:

$$\varphi(t,t_o)=\phi_o\beta_c(t,t_o) \qquad (17)$$

Where:
φ_o= creep factor and $\beta c(t-t_o)$ characterizes the growth of creep according to time.

The creep factor can be calculated by:

$$\phi_o=\phi_{RH}\beta(f_{cm})\beta(t_o) \qquad (18)$$

$$\phi_{RH}=1+\frac{1-RH/100}{0.46(h/4)^{1/3}} \qquad (19)$$

$$\beta(f_{cm})=\frac{5.3}{(f_{cm}/1450)^{0.5}} \qquad (20)$$

$$\beta(t_o)=\frac{1}{0.1+t_o{}^{0.2}} \qquad (21)$$

Where:
RH = qualified moisture, h = two times the cross section of structural part divided by the boundary in interaction with the environment, t_o = concrete middle age at submission of load per day of faster drying is about 7 days of humid drying.

The growth of creep according to time is determined according to the next equation:

$$\beta_c(t-t_o)=\left[\frac{t-t_o}{\beta_H+(t-t_o)}\right]^{0.3} \qquad (22)$$

$$\beta_H=150\left[1+(0.012RH)^{18}\right]\frac{h}{4}+250\leq1500 \qquad (23)$$

The relation between shrinkage strain and time is denoted by:

$$\varepsilon_{cs}(t-t_s)=\varepsilon_{cso}\beta(t-t_s) \qquad (24)$$

Where:
ε_{cso} = the shrinkage factor, $\beta s(t-ts)$ = the growth of shrinkage within time.

The shrinkage factor is calculated by:

$$\varepsilon_{cso}=\varepsilon_s(f_{cm})\beta_{RH} \qquad (25)$$

$$\beta_{Rh}=-1.55\left[1-(RH/100)^3\right] \qquad (26)$$

$$\varepsilon_s(f_{cm})=\left[160+10\beta_{sc}(9-\frac{f_{cm}}{1450})\right]\times10^{-6} \qquad (27)$$

β_{sc} = parameter secretarial for cement kind.

The growth of shrinkage according to time is determined according to following equation:

$$\beta_s(t-t_o) = \sqrt{\frac{(t-t_s)}{\left[350(\frac{h}{4})^2 + (t-t_s)\right]}} \quad (28)$$

AASHTO – LRFD MODEL

The AASHTO LRFD standards model to calculate creep factor and shrinkage straining, in addition to the approvals of the CEB-FIP model and ACI-209 (AASHTO, 1998)

Creep factor, ψ(t,ti), is calculated by:

$$\psi(t,t_i) = 3.5K_cK_f(1.58 - \frac{H}{120})t_i^{-0.118}\frac{(t-t_i)^{0.6}}{10+(t-t_i)^{0.6}} \quad (29)$$

$$K_f = \frac{1}{0.67 + (\frac{f`_c}{9})} \quad (30)$$

$$K_c = \left[\frac{\frac{t}{26e^{0.36v/s}+t}}{\frac{t}{45+t}}\right]\left[\frac{1.80+1.77e^{-0.54v/s}}{2.587}\right] \quad (31)$$

Where:
K_c = parameter of influencing volume/surface proportion of the structural part, K_f = parameter of influencing concrete compression strength, H = qualified moisture in percentage, t_i = concrete middle age at submission of the creep containing load/days, and t = concrete middle age at which the creep factor is favorite.

Shrinkage straining (ε_{sh}) within time (t) for vapor dried concrete voiding of shrinkage-disposed to aggregates is determined using:

$$\varepsilon_{sh} = -K_sK_h(\frac{t}{55+t})0.56\times10^{-3} \quad (32)$$

$$K_s = \left[\frac{\frac{t}{26e^{0.36v/s}}}{\frac{t}{45+t}}\right]\left[\frac{1064-94v/s}{923}\right] \quad (33)$$

$$K_h = \frac{140-H}{70} \quad \text{for} \quad H<80\% \quad (34)$$

$$K_h = \frac{3(100-H)}{70} \quad \text{for} \quad H\geq80\% \quad (35)$$

Where:
Ks = dimensions parameter, K_h = parameter for the qualified moisture, t = concrete middle age at the time for shrinkage strain which is calculated per days.

SHAMS AND KAHN MODELS

Shams and Kahn, 2000 established adjustments of AASHTO LRFD terms to determine creep and shrinkage parameters for explanation to reduce creep and shrinkage straining which showed by HPC. The adjustments consist of new parameters to description for the relation of stress and strength proportion due to loads application time, the time length of the humid drying, and the concrete middle age at the beginning of drying. Moreover, the parameters for concrete compression strength and concrete middle age due to loads submission have been improved. Creep factor is determined using:

$$\phi_t = 2.73K_{vs}K_{fc}K_hK_{t`}K_\sigma K_m\frac{(t-t`)}{d+(t-t`)^{0.6}} \quad (36)$$

$$K_{fc} = \frac{4.8}{1.645+f`_c} \quad (37)$$

$$K_h = 1.58 - 0.83h \quad (38)$$

$$K_{t`} = 0.65e^{0.7/(t`+0.57)} \quad (39)$$

$$K_\sigma = e^{1.5(\Gamma-0.4)}, for 0.4 \prec \Gamma \leq 0.6 \quad (40)$$

$$K_\sigma = 1.0, for \Gamma \leq 0.4 \quad (41)$$

$$K_m = 1 + 0.65(1-e^{-0.59m})^{5.73} \quad (42)$$

$$d = \frac{t`}{0.356+0.09t`} \quad (43)$$

Where:
K_{vs} = dimensions parameter, K_{fc} = parameter for concrete strength, K_h = qualified moisture parameter, k_t = parameter of middle age concrete at applied load, k_σ = stress /strength proportion parameter, k_m = humid drying time parameter, t = concrete middle age per days, f'c = compressive strength of concrete at 28 days (ksi), h = qualified moisture, Γ= proportion of submitted stress at applied load divided by concrete strength, and m = humid drying time per days. Shrinkage straining can be determined by:

$$\varepsilon_{sh}(t,t_o) = \varepsilon_{sh\infty}K_HK_{to}\left[\frac{t-t_o}{23+(t-t_o)}\right]^{0.5} \quad (44)$$

for accelerated cured concrete:

$$\varepsilon_{sh\infty} = 510\mu\varepsilon \quad (45)$$

for moist cured concrete:

$$\varepsilon_{sh\infty} = 560\mu\varepsilon \quad (46)$$

$$K_{to} = 0.67e^{4.2/9.45+t_o} \quad (47)$$

Where:
$\varepsilon_{sh\infty}$ = critical shrinkage strain, k_{vs} = parameter of volume/ apparent area, k_H = qualified moisture parameter, k_{to} = parameter secretarial of dried concrete, t = concrete middle age (day), t_o= concrete middle age at the beginning of drying (days).

NCHRP REPORT NO. 496 MODEL

NCHRP report No. 496 defined creep model by adopting creep parameter, which is the proportion of strain after applied loads divided by elastic strain. Therefore, creep factor can be calculated by:

$$\psi(t,t_o) = 1.90\gamma_{cr} \quad (48)$$

$$\gamma_{cr} = K_{td}K_{la}K_sK_{hc}K_f \quad (49)$$

$$K_{td} = \frac{t}{61-4f^{`}{}_{c}+t} \quad (50)$$

$$K_{la} = t_i^{-0.118} \quad (51)$$

$$K_s = \frac{1064-94v/s}{735} \quad (52)$$

$$K_{hc} = 1.56-0.008H \quad (53)$$

$$K_f = \frac{5}{1+f_c^{`}} \quad (54)$$

Where:
k_{td} = time growth parameter, k_{la} = load age parameter for 7 days of humid drying, k_s = dimensions parameter, k_{hc} = parameter of moisture for creep, k_f = parameter of compressive strength for concrete, f'ci = compressive strength for concrete at relief (ksi), V/S= proportion of volume divided by surface (in), H = % qualified moisture. The shrinkage strain is determined by:

$$\varepsilon_{sh} = 480\times10^{-6}\gamma_{sh} \quad (55)$$

$$\gamma_{sh} = K_{td}K_sK_{hs}K_f \quad (56)$$

$$K_{hs} = 2.00-0.0143H \quad (57)$$

Where:
K_{hs}= moisture parameter for shrinkage.

B3 MODEL (BAZANT AND BAWEJA, 1995)

Bazant and Baweja developed creep and shrinkage model at Northwestern University in 1995. Their model was standardized for average compressive strengths of concrete which are ranged between 2.5ksi and 10ksi, with a proportion of aggregate/cement according their weight extending between 2.5 and 13.5, cement content extending between 10pcf and 45pcf, and a proportion of water / cement is ranged from 0.30 to 0.85. This model is additional boundless by experimental statistics to creep happening at a qualified moisture is ranged from 40% to 100% (Bazant & Baweja, 1995a,b,c).

The shrinkage straining (εsh(t)) is calculated in a process like the previous simulations. The overall straining at constant temperature is determined using:

$$\varepsilon(t) = j(t,t^{`})\sigma + \varepsilon_{sh}(t) \quad (58)$$

Where:
σ = un-axial stresses.

The creep submission utility can be decayed by using three ways:

$$j(t,t^{`}) = q1 + C_o(t,t^{`}) + C_d(t,t^{`},t_o) \quad (59)$$

Where:
q1 = immediate elastic strain, C_0(t,t') = submission utility for basic creep at time (t') of applied load, $C_d(t,t',t_0)$= submission utility for further creep at time (t') of applied load because of drying created within time ($t_{0)}$. Immediate elastic straining is determined by:

$$q1 = \frac{0.6\times10^6}{E_{28}} \quad (60)$$

$$E_{28} = 57000\sqrt{f^{`}{}_{c}} \quad (61)$$

Where:
E_{28}= modulus of elastic in 28-day, f'c = concrete compression strength in 28-day (psi).

Creep submission utility is determined by:

$$C_o(t,t^{`}) = q2Q(t,t^{`}) + q3\ln\left[1+(t-t^{`})^n\right] + q4\ln(\frac{t}{t}) \quad (62)$$

Where:
Q(t,t') = binomial essential can't be stated methodically

$$Q(t,t^{`}) = Q_f(t^{`})\left[1 + \left(\frac{Q_f(t^{`})}{Z(t,t^{`})}\right)^{r(t^{`})}\right]^{-1/r(t^{`})} \quad (63)$$

$$Q_f(t,t^{`}) = \left[0.086(t^{`})^{2/9} + 1.21(t^{`})^{4/6}\right]^{-1} \quad (64)$$

$$Z(t,t^{`}) = (t^{`})^{-m}\ln\left[1 + (t - t^{`})^{n}\right] \quad (65)$$

$$r(t^{`}) = 1.7(t^{`})^{0.12} + 8 \quad (66)$$

Where:

$$q2 = 451.1c^{0.5}(f^{`}_{c})^{-0.9} \quad (67)$$

$$q3 = 0.29(w/c)^{4} q2 \quad (68)$$

$$q4 = 0.14(a/c)^{-0.7} \quad (69)$$

Where:
C = cement content , w/c = water /cement proportion, a/c = proportion of aggregate to cement.

The submission utility for drying creep can be determined by:

$$C_d(t,t_o) = q5\left[e^{-8H(t)} - e^{-8H(t^{`})}\right]^{1/2} \quad (70)$$

$$q5 = 7.57 \times 10^{5} f^{`}_{c}{}^{-1}\varepsilon^{-0.6}{}_{sh\infty} \quad (71)$$

H(t)=1-(1-h)S(t) (72)

Where:
$\varepsilon_{sh\infty}$= critical shrinkage strain, h = qualified moisture, S(t) = time utility for shrinkage.

This needs to calculate the critical shrinkage ($\varepsilon_{sh\infty}$), a moisture adjustment parameter (kh), and shrinkage period utility S(t). Value of shrinkage within time (t) is determined by:

$$\varepsilon_{sh}(t,t_o) = -\varepsilon_{sh\infty}K_h S(t) \quad (73)$$

$$\begin{aligned} K_h &= 1 - h^{3}, for h \le 0.98 \\ K_h &= -0.2, for h = 1(swelling in water) \\ K_h &= linear - interpolation, for 0.98 \le h \le 1 \end{aligned} \quad (74)$$

$$S(t) = \tanh\left[\frac{t - t_o}{\tau_{sh}}\right]^{1/2} \quad (75)$$

$$\tau_{sh} = K_t(K_s D)^{2} \quad (76)$$

$$K_t = 190.8t^{-0.08}{}_{o}(f^{`}_{c})^{-0.25}, in, days/in^{2} \quad (77)$$

$$D = \frac{2V}{S} \quad (78)$$

ks = cross-section form parameter, the critical shrinkage is determined by:

$$\varepsilon_{sh\infty} = \alpha 1\alpha 2\left[26w^{2.1}(f^{`}_{c})^{-0.28} + 270\right] \quad (79)$$

$$\begin{aligned} \alpha 1 &= 1.0, for - type(I), cement \\ \alpha 1 &= 0.85, for - type(II), cement \\ \alpha 1 &= 1.1, for - type(III), cement \end{aligned} \quad (80)$$

GARDENER AND LOCKMAN, 2001 MODEL (GL2000)

Gardener & Lockman, 2001 established model to determine creep and shrinkage parameters depending on a methodology suggested via Gardener & Zhao, 1993 previously, and it was improved according to Gardener, 2000. The model determines creep and shrinkage parameters by adopting information which is obtainable to the civil engineer during design stage of the civil project. The main responses to the model are the average compression strength of concrete, qualified moisture, the kind of cement, the age when drying stage starts, the age when force is subjected, the proportion of volume/surface of structural part subjected to load, and the applied stress. The overall strain for constant temperature can be determine by:

$$\varepsilon(t) = \varepsilon_{sh} + \left(\frac{1}{E_{cmto}} + \frac{\phi_{28}}{E_{cm28}}\right)\sigma \quad (81)$$

Where:
ε_{sh} = shrinkage strain, E_{cmto}= concrete modulus of elasticity (psi), φ_{28}= creep factor, E_{cm28}= concrete modulus of elasticity at 28-days (psi), σ = applied stress (psi).
When the experimental information about concrete modulus of elasticity is unobtainable, it can be determined by:

$$E_{cmt} = 510000 + 52000\sqrt{f_{cmt}} \quad (82)$$

Where:
E_{cmt} = concrete elasticity modulus (psi), F_{cmt} = concrete compression strength (psi).

Creep factor is founded using the equation below:

$$\phi_{28} = \phi(t_c)\left[2\left(\frac{(t-t_o)^{0.3}}{(t-t_0)^{0.3}+14}\right) + \left(\frac{7}{t_0}\right)^{0.5}\left[\frac{t-t_o}{t-t_{o+7}}\right]^{0.5} + \right]\left[2.5(1-1.086h^{2})\left(\frac{t-t_o}{t-t_o+97(v/s)^{2}}\right)^{0.5}\right] \quad (83)$$

$$\phi(t_c) = 1, for, t_o = t_c \quad (84)$$

$$\phi(t_c) = \left[\left(1 - \left(\frac{t_o - t_c}{t_o - t_c + 97(v/s)^{2}}\right)^{0.5}\right)0.5\right] for, t_o \succ t_c \quad (85)$$

Where:

t_0= concrete middle age during application of load, t_c= concrete middle age when drying begins per days, h = qualified moisture, V/S = proportion volume/surface of the structural member.

The shrinkage strain can be calculated by:

$$\varepsilon_{sh} = \varepsilon_{shu}\beta(h)\beta(t) \quad (86)$$

$$\varepsilon_{shu} = 1000.K.\left(\frac{4350}{f_{cm28}}\right)^{1/2} \times 10^{-6} \quad (87)$$

$$\beta(h) = 1 - 1.18h^4 \quad (88)$$

$$\beta(t) = \left(\frac{t - t_c}{t - t_c + 97(v/s)^2}\right)^{0.5} \quad (89)$$

Where:

f_{cm28} = average concrete compression strength within 28 days, K can be determined by:

K=1 for category (I) cement
K=0.70 for category (II) cement
K=1.15 for category (III) cement

$$f_{cmt} = f_{cm28}\frac{t^{3/4}}{a + bt^{3/4}} \quad (90)$$

Where:

a = 2.8 (category (I) cement); a = 3.4 (category (II) cement), a= 1.0 (category (III) cement); b= 0.77 (category (I) cement); b= 0.72 (category (II) cement), b= 0.92 (category (III) cement).

AFREM -MODEL

AFREM model defined according to Le *et. al*. 1996 and they were specially established this model to calculate creep and shrinkage. The main responses to the model are the average compressive strength of concrete, qualified moisture, the kind of cement, the age when drying stage starts, the age when force is subjected, the proportion volume/surface of the structural part subjected to load, and the applied stress. The overall straining of concrete is the summation of elastic straining, creep straining, and shrinkage straining. It can be determined using:

$$\varepsilon_{cr}(t,t^`) = \frac{\sigma(t^`)}{E_{28}}(\phi_b(t,t_o) + \phi_d(t,t^`)) \quad (91)$$

Where:

σ(t') = stress applied on concrete (ksi), E_{28} = concrete modulus of elasticity within 28 days (ksi), φ_b(t, t') = creep parameter, φ_d(t, t') = drying creep factor, t= concrete age in days, t' = concrete age within time of application of load in days, the overall creep is combined of humid creep and dried creep. Humid creep is determined by:

$$\phi_b(t,t^`) = \phi_{bo}\frac{\sqrt{t-t^`}}{\beta_{bc} + \sqrt{t-t^`}} \quad (92)$$

$$\phi_{bo} = \frac{1.762}{f^`_{ci}} \text{ for micro-silica concrete} \quad (93)$$

$$\phi_{bo} = 1.4 \text{ for non-micro-silica concrete} \quad (94)$$

$$\beta_{bc} = 0.37e^{(2.8f^`_{ci}/f^`_c)} \text{ for micro-silica concrete} \quad (95)$$

$$\beta_{bc} = 0.40e^{(3.1f^`_{ci}/f^`_c)} \text{ for non-micro-silica concrete} \quad (96)$$

Where:

$\varepsilon_{sh}(t,t_0)$ = drying shrinkage due to begging of drying at time (t), $\varepsilon_{sh}(t',t_0)$= drying shrinkage due to submission of load at time (t).

Dried shrinkage is determined using:

$$\varepsilon_{sh}(t,t_o) = \frac{K(f^`_c)\left(72e^{-0.3172f^`_c} + 75 - 100h\right)}{\beta_{dso}\left(50.8^{A_c/u}\right)^2 + (t-t_o)}(t-t_o)\times(10^{-6}) \quad (97)$$

$$K(f^`_c) = 18 \text{ for } f^`_c \leq 8.25 \quad (98)$$

$$K(f^`_c) = 30 - 1.448f^`_c \text{ for } f^`_c \geq 8.25 \quad (99)$$

$$\beta_{dso} = 0.007 \text{ for micro-silica}$$

$$\beta_{dso} = 0.021 \text{ for non-micro-silica}$$

Where:

h= qualified moisture, Ac = concrete cross section area (*in*²), u = exposed boundary of e concrete (in).

CONCLUSION

1. Time-dependent analysis is significant and essential for two types of prestressed concrete (pretensioned and posttensioned) with the influence of time, properties variations in the structural pattern, and high erection loads influence the structural performance and protection of structure for the duration of erection and when complete.
2. Shrinkage and creep are the main time-dependent parameters of concrete. They are important parameters in the design of prestressed concrete structures such as bridges. Shrinkage and creep influence the properties variations of concrete in length over time. They are effected by features of concrete, exposure situations air and erection steps, which are in sequence for prestressed concrete structures
3. The objective of this study is to review the difference between analysis models of time-dependent parameters for prestressed concrete bridges. Creep and shrinkage parameters are selected to review the effect of these parameters on the properties of prestressed concrete. Nine methods of analysis for creep and shrinkage of

concrete were reviewed in this study. These models include ACI-209 model, PCI-BDM model, CEB-FIP-90 model, AASHTO-LRDF model, Shams and Kahan model, NCHRP-496 model, B3 model, GL2000 model, and AFREM model.

ACKNOWLEDGEMENT

This work was supported by the Al-Furat Al-Awsat Technical University, Iraq.

DECLARATION OF COMPETING INTEREST

None

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