COMPARATIVE ANALYSIS BETWEEN TWO STANDARDS TCVN 5574:2018 AND TCVN 5574:2012

Part 3: Comparison of calculation methods in two quality standards

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ABSTRACT

In the new standard TCVN 5574:2018, replacing TCVN 5574:2012, there are significant changes in structure, materials and calculation methods compared with the old version TCVN 5574:2012. The standard TCVN 5574-18 has approached EC2 and ACI standards to increase international integration, and it has also changed the perspective of computational modeling, converted from stress model to strain model. This article analyzes and compares two standards to highlight new points, helping designers to distinguish easily and conveniently apply TCVN 5574:2018 in practice. To achieve the goal, the authors organize into five main contents as follows: Part 1: Some general notes; Part 2: Comparison of materials in two quality standards; Part 3: Comparison of calculation methods in two quality standards; Part 4: Evaluation method and analysis of results.

Keyword: *TCVN 5574:2018, TCVN 5574:2012, Reinforced concrete, Standard, Strain model*

1. INTRODUCTION

The design standards of reinforced concrete structures of countries around the world are often updated and changed regularly. The period for updating and modifying is usually about every 3 years and renewal about every 10 years. The current standard for the design of concrete and reinforced concrete structures TCVN 5574:2018 [2] took effect from December 10, 2018, and replaces the old version of TCVN 5574:2012 [1]. TCVN 5574:2012 [1] was published in 2012. It has been moved from TCXDVN 356:2005 [3] and had been retained in its entirety, only renamed. Furthermore, TCXDVN 356:2005 is translated from the Russian standard SNIP 2.03.01-84 which was made more than 30 years ago. Thus, we had used too old standards compared with the progress of science and technology in the world. This problem had caused many inadequacies in the design process. Standard [1] stipulates the use of steels (such as CI, C-II, C-III...) according to the old standards before, so it is not linked with the new standards of Vietnam. as standard on current reinforcement steel, or prestressed steel (pre-stressed): TCVN 1651:2008 [4], TCVN 6284:1997 [5, 6, 7], TCVN 6288:1997 [8].

Therefore, to update new information in the field of design of concrete and reinforced concrete structures, standard [1] has been replaced by TCVN 5574:2018 [2]. This standard has been written mainly based on the Russian standard SP 63.13330.2012. With this approach, it will not cause much confusion in teaching and designing practice. In this new standard [2], it has many new points that deserve attention: the calculation perspective is changed from the stress model to the strain model (accepting the flat section assumption), calculating Puncture math and other new points are presented below.

2. MAIN CONTENT

Standard 5574:2018 has updated new solutions, gradually approaching the EC2 standard. The new method is based on simple but versatile computational models. It has reduced the experimental coefficients in the formula and taken into account the world's published reliable verified experimental results.

The basic foundation for the calculation of concrete and reinforced concrete members which are subjected to bending moments and forces along with the limit state groups (first and second) is a nonlinear strain model (both of concrete and reinforcement). In which, in addition to using the balance equations, the deformation conditions are still followed with the assumption of flat cross-section and the complete strain diagram of concrete and reinforcement. This model allows calculations on the same view for any concrete and reinforced concrete members with different cross-sectional shapes. It also allows the different arrangement of longitudinal reinforcement and takes into account the elastic-plastic properties of concrete and reinforcement and the stress-deformation state of reinforced concrete members. In addition, the members with simple and popular cross-sections such as rectangular, T-shaped, and I-shaped sections, in the new standard [2], it is also possible to use simpler calculation methods.

Table 3. Comparison of calculation methods

Numerical order	**TCVN 5574:2018**	**TCVN 5574:2012 (356-2005)**
1	Calculation contents of concrete, reinforced concrete, and prestressed concrete structures are separated.	It was confusing when presenting related contents: concrete properties, reinforced concrete, prestressed concrete.
2	Calculated according to the first limit state: - State the nonlinear deformation model when calculating. - The common cross-sections (rectangular, T, I) still allow calculation according to internal force. - The height of the concrete domain in tension is simpler. $\xi_R = \frac{x_R}{h_0} = \frac{0.8}{1+\frac{\varepsilon_{s,el}}{\varepsilon_{b2}}}$ (4) $\varepsilon_{s,el}$: Relative strain of tensile reinforcement, when $\sigma_S = R_S \left(\varepsilon_{S,el} = \frac{R_S}{E_S} \right)$ (5) ε_{b2}: Relative deformation of concrete under compression when $\sigma_b = R_b$ - Short load: B ≤ 60: $\varepsilon_{b2} = 0.0035$ B ≥ 70: ε_{b2} is linearly interpolated from 0.0033 (B70) to 0.0028 (B100) and then the factor 0.8 is taken as 0.7. - Long-term load: ε_{b2} according to table 9, depending on humidity (specific number is available). - With flexural members, when checking, there is $\xi > \xi_R$, taking $\xi = \xi_R$, the calculation should be simpler to apply. - With flexural members, place reinforcement symmetrically (meet when checking piles during transportation, crane installation) $M_u = R_s A_s (h_0 - a')$ (7) If x (calculated with $A'_s = 0$) has x < 2a', take x =2a', the calculation continues. - For members subjected to large eccentric compression: additional random eccentricity ea ≥ 10mm. $e_0 = \frac{M}{N} + e_a$ (9)	Calculated according to the first limit state.: - Not stating the calculation according to the nonlinear strain model. - Only calculated according to the internal force limit. - The height of the concrete area under compression. $\xi_R = \frac{\omega}{1+\frac{\sigma_{SR}}{\sigma_{SC,u}}\left(1-\frac{\omega}{1.1}\right)}$ (6) $\omega = \alpha - 0.008 R_b n$ α = 0.85 for heavy concrete $\sigma_{SR} = R_s$ ordinary concrete $\sigma_{SC,u} = 500MPa$ (long term load) $\sigma_{SC,u} = 400MPa$ (short-term load) with flexural members, when $\xi > \xi R$, ξ must be redefined, according to the stress value in the reinforcement. $\sigma_S = \frac{0.2+\xi_R}{0.2+\xi+0.35\frac{\sigma_{sp}}{R_S}\left(1-\frac{\xi}{\xi_R}\right)} R_S < R_S$ (8) $\sigma_{sp} = 0$ if it is ordinary reinforced concrete - Symmetrical steel in rectangular members has not been specified (but TCVN 5574-91 has similar regulations 5574-18). - For eccentric compression members, it is necessary to consider e_a . $e_a \geq l_0$; $e_a \geq h/30$

	- For members with large eccentric compression, rectangular cross section, (8.1.2.4.1) stated. when $\xi \le \xi_R$: $$X = \frac{N + R_S A_S - R_{SC} A'_s}{R_b b} \quad (10)$$ when $\xi > \xi_R$: $$x = \frac{N + R_S A_S \frac{1+\xi_R}{1-\xi_R} - R_{SC} A'_S}{R_b b + \frac{2R_S A_S}{h_0\left(1-\xi_R\right)}} \quad (11)$$	- With eccentric compression member, $\xi \le \xi_R$: constant. If $\xi > \xi R$ the formulas to calculate x, in terms of $\sigma s < Rs$, are complicated.
2	The longitudinal coefficient of bending is simpler. $$\eta = \frac{1}{1-\frac{N}{N_{cr}}}; N_{cr} = \frac{\pi^2 D}{L_0^2} \quad (12)$$ $D=k_b E_b I+k_s E_s I_s$ (I, I_s calculated for the centroid of the cross-section.) $k_s = 0.7$; $$k_b = \frac{0,15}{\varphi_L\left(0,3+\delta_e\right)}$$ $$\varphi_L = 1+\frac{M_{L1}}{M_L} \quad (13)$$ M_L is the moment taken with the center of the steel bar most in tension or in least compression (when the entire cross-section is in compression) when subjected to the full load. M_{L1} is the moment taken with the center of the steel bar with the most tension or the least compression (when the entire cross-section is in compression) when subjected to permanent and temporary long-term loads. δ_e is the relative eccentricity value of the longitudinal force (δ_e = e h_0), taken not less than 0.15 and not more than 1.5. Centered compression member: when e_0 is small or $e_0 = 0$: center compression when $e_0 \le h/30$; $L_0/ h \le 20$: Small eccentric compression. $$N \le N_u$$ $$N_u = \varphi\left(R_b A + R_{sc} A_{s,tot}\right) \quad (14)$$ -Short-term load: φ linear interpolation. between φ=0.9 with L_0/h =10; φ=0.85 with L_0/h =20. -For long-term loading: see table 16 (5574-18), according to the strength class of concrete. - Calculation length l_0: +For multi-layer frames, each floor is considered as a soft-gap link (the lower end is fixed, the upper end allows a limited angle of rotation); $l_0=0.9h_t$ + Calculation according to the nonlinear deformation model, on the perpendicular section: setting for any symmetrical cross-section, subjected to bending, oblique bending, and oblique eccentric compression at the same	Calculating the value of $\boldsymbol{\eta}$ is more complicated. $$N_{cr} = \frac{6.4E_b}{L_0^2}\left[\frac{1}{\varphi_1}\left(\frac{0.11}{0.1+\frac{\delta_c}{\varphi_b}}+0.1\right)+\alpha I_S\right]$$ The coefficients of N_{cr} are more complicated Compression member at the center: not specified in detail, the longitudinal bending coefficient φ is different. l_0 defined for frames is simple for industrial buildings but complex for trusses and arches; usually l_0 = $0,7h_t$ The calculation according to the nonlinear strain model is not stated.

	time, the algorithm is still complicated, even difficult to understand (due to no accompanying theory). - Rectangular section, T, I (box), allowed to calculate according to limited internal force (same as old standard); The formula for determining $\boldsymbol{\xi}$, $\boldsymbol{\eta}$ is different.	
3	Calculation of reinforced concrete structure according to inclined section: similar to TCVN 5574-12, three failure diagrams on inclined section are explained more clearly. $Q \le \varphi_{b1} R_b b h_0 \left(\varphi_{b1} = 0.3\right)$ (15) If it does not satisfy the equation, the strength grade or section size must be increased. Do not consider components $Q_{s,inc}$ anymore (reinforcing oblique). Undefined c_0, but it has to be calculated with inclined sections, with $h \le c \le 2h_0$	$Q \le 0.3\varphi_{w1}\varphi_{b1} R_b b h_0$ (16) If the above conditions are not satisfied, the cross-sectional size or durability level of concrete must be increased. Consider $Q_{s,inc}$
4	Calculation of torsional bending structures: Simpler and completely different. Determine the pure twist formula: $T \le 0.1 R_b b^2 h;\ \ T = T_{sw} + T_s$ (17) Determine the formula for torsion and bending: $T \le T_0 \sqrt{1 - \left(\frac{M}{M_0}\right)^2}$ (18) Determine the torsion formula combining shear force: $T \le T_0 \left(1 - \frac{Q}{Q_0}\right) T_0 = 0.1 R_b b^2 h$ (19)	Calculate the member subjected to torsional bending for (M, M_x) and (Q, Q_x).
5	Calculation by puncture condition with reference to ACI 318 and EC2: performed in four cases.	Calculation of puncture: simple, similar to that of a punctured nail. The anti-puncture belt is not strictly regulated, not guaranteed.
6	It allows to check the floor slab according to the shear force if necessary. $\frac{Q_x}{Q_{x,u}} + \frac{Q_y}{Q_{y,u}} \le 1 \quad Q_{x(y),u} = Q_b + Q_{sw} \quad Q_b = 0.5 R_{bt} b h_0 \ \&\ Q_{sw} = q_{sw} h_0$ (20)	The slab always meets the shear condition.
7	Flat wall (wall): - Method 1: Cut each flat element 1 x 1 xd (wall thickness), subject to all the applied internal forces (M_x, M_y, N_x, N_y, torque and shear force) along the edges (8.1.7.4) . - Method 2: Divide the flat element into layers (1m wide or more) of concrete in compression and steel in tension. Then calculate each layer under the influence of the normal force and the shear force in the layer. These forces are caused by the general M, T, and N acting in the plane (8.1.7.5). This is quite common. - At this time, the out-of-plane calculation is performed similarly to the steel calculation for the normal slab.	Flat wall (wall): not mentioned.
8	Loss of prestress: 8 types left (reviewed twice)	Prestress loss: 11 types
9	Reinforcement content: Min 0,1% for members subjected to bending, tension and eccentric compression with $l_0/i \le 17$ or $l_0/h \le 5$ (rectangular).	No details

	Min 0.25% for eccentric compression when l_0/i >87 hay $l_0/h \geq 25$ take double value, when the steel section is arranged according to the circumference.	
10	It is necessary to arrange longitudinal reinforcement for flat plates in 2 directions on the lower and upper faces of the plates.	No mention

3. CONCLUSIONS

The design standard of concrete and reinforced concrete structures TCVN 5574-18 has gradually approached the EC2 standard and a little approach to ACI (ε_b = 0.003). It has changed the view of computational modeling and has moved from the stress model to the strain model. This model is recommended to be used as a priority for calculation according to limit states (first and second) for members subjected to bending moments and longitudinal forces. It still allows úing the limited internal force method for members with simple cross-sectional shapes such as rectangle, T, and I.

TCVN 5574-18 has added: how to calculate steel for floors and walls; The breakdown calculation allows to take into account the influence of bending moments in both directions, which is different from the previous standard which has not been taken into account. The calculation of local compression is still the same as the previous model, but the calculation formula is adjusted.; The torsion calculation still uses a spatial model according to the limited internal force method, but uses interaction diagrams when the bending moment and the torque, as well as the shear force and the torque, are applied simultaneously.

TCVN 5574-12 has not been detailed, even omitted, so it was confusing to apply. As it did not state the establishment of calculation equations for members with any symmetrical cross-section, the establishment of calculation equations for other common cross-sections. At that time, the nonlinear deformation model was complicated and difficult to apply in practice, especially in oblique bending, oblique eccentric compression. It has not established the calculation method of tension and compression members eccentrically T, I, box. It also did not establish how to calculate A_s, when there are As, Asp in tension concrete. It did not set l0 for industrial columns, cranes, trusses, and domes.

4. ACKNOWLEDGEMENT

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5. REFERENCES

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