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Automated RC-column design to TCVN 5574:2018 using excel VBA – CSi API integration

Le Hoang[1*], Le Thi Anh Hong[1], Do Hung Thoi[1], Le Quoc Hai[2], Nguyen Van Tam[2], Tran Duc Thuong[3], Bui Le Anh Tuan[4]

[1] Civil Engineering Faculty – Can Tho University of Technology

[2] Department of Construction of Can Tho City

[3] Faculty of Construction Engineering, Tay Do University

[4] Civil Engineering Faculty – College of Engineering – Can Tho University

KEYWORDS

CSi API
VBA Excel
Reinforce concrete
Longitudinal bar
Stirrup bar

ABSTRACT

In the Vietnamese structural engineering context, designing reinforced concrete columns to the updated standard TCVN 5574:2018 often involves time-consuming manual processes because mainstream software like ETABS does not yet natively support this code. This paper introduces an automated design approach directly linking ETABS with Excel through the CSi application programming interface (API), eliminating manual data export or import. The design procedure is implemented using Excel's Visual Basic for Applications (VBA) and CSi API macros, which programmatically control ETABS to control the model, retrieve analysis results and perform iterative design calculations to meet code requirements. By integrating analysis and design in a single automated loop, the workflow significantly accelerates the column design process and minimizes human errors compared to traditional manual or semi-manual methods. The verified results show that the tool can design multiple columns faster and more efficient compared to conventional common methods. This efficient workflow saves time and provides a foundation for future enhancements, such as linking the system to AutoCAD for automatic reinforcement detailing.

1. Introduction

In the evolving landscape of structural engineering, the demand for efficient, accurate, and code-compliant design workflows has never been more critical—especially in regions where national codes are rapidly modernizing. In Vietnam's structural engineering practice, ETABS is the dominant software used to analyse and model reinforced concrete (RC) structures. However, despite its advanced capabilities, ETABS does not natively support the latest Vietnamese standard TCVN 5574:2018 [1] for concrete design. This led to a common but fragmented workflow: engineers perform analysis using ETABS, export results manually, and then use spreadsheets or hand calculations. This fragmented approach consumes time and introduces significant potential for human error, limiting the benefits of otherwise powerful analysis tools.

The TCVN 5574:2018 standard represents a significant advancement in Vietnam's regulatory framework for reinforced concrete structures, replacing the older 2012 version [2] that itself retained elements from a Soviet-era 1984 standard (SP 63.13330.2012 [3]). The new version incorporates modernized provisions for strength design, cross-sectional reinforcement, and structural safety, aligning Vietnam's practice more closely with international engineering developments. Despite this progress, commercial structural software packages—including widely used platforms like ETABS—have not yet fully integrated design modules compatible with TCVN 5574:2018. As a result, engineers are left to bridge the gap themselves, typically by exporting internal force data manually and verifying design compliance via Excel-based templates. While spreadsheet solutions using Visual Basic for Applications (VBA) can accelerate calculation routines, they remain largely disconnected from the analysis environment, creating bottlenecks in data exchange and undermining the reliability and repeatability of code-based checks [4-11].

Meanwhile, the global construction industry is transforming digitally, driven by technologies such as Building Information Modeling (BIM), digital twins, and real-time data integration. Similar initiatives in Vietnam are gaining momentum through government policy and industry partnerships. However, the lack of integrated, locally relevant digital tools remains a pressing issue. Besides the local Dbim software, most design automation solutions currently used in Vietnam either do not support direct interaction with national design codes or do not integrate natively with established structural analysis software. This technology disconnect presents an opportunity for targeted innovation—especially through the use of open APIs.

One such solution is leveraging the Application Programming Interface (API) provided by CSI's ETABS software. The ETABS API offers programmatic access to the platform's analysis engine, enabling developers and engineers to extract structural results, automate design calculations, and even modify models from external applications [12-

*Corresponding author: lhoang@ctuet.edu.vn

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15]. Excel VBA, in particular, presents a promising integration point, as it is both familiar to most engineers and sufficiently powerful for mid-scale automation. Embedding API calls directly into VBA scripts within Excel workbooks enables the automated retrieval of analysis results—such as axial forces and moments for RC columns—and the immediate execution of reinforcement calculations following TCVN 5574:2018.

This study proposes an integrated solution that leverages the open Application Programming Interface of ETABS within a Visual Basic for Applications (VBA) environment in Excel. By embedding API calls directly into VBA scripts, analysis data such as internal forces can be retrieved automatically and used to perform reinforcement calculations compliant with TCVN 5574:2018. The integration of the CSi API with Excel VBA directly addresses this limitation. The process of assuming initial Muy values, computing reinforcement demands, and checking code compliance can be embedded into a looped VBA routine through automation. This seamless workflow reduces manual steps and errors and verifies consistent, code-compliant design. Despite the powerful capabilities of the CSi API, its adoption in Vietnam remains limited, partly due to the lack of open-source examples and technical guidance. This research aims to demonstrate the practical application of this integration, offering a replicable approach for automating RC column design according to current Vietnamese standards.

2. Methodology

This study adopts a computational approach to develop an automated workflow for the design of reinforced concrete columns in accordance with TCVN 5574:2018, leveraging the CSi Application Programming Interface integrated with Visual Basic for Applications in Microsoft Excel. As illustrated in Figure 1, the methodology is structured into five interconnected stages, supporting a streamlined transition from structural analysis to code-compliant reinforcement design.

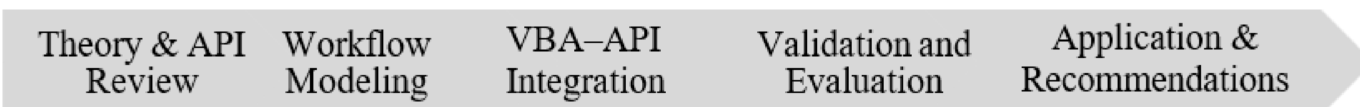


Figure 1. Implementation Process for RC Column Design Automation.

The proposed framework links Microsoft Excel VBA with the CSi Open-API (ETABS/SAP2000) to automate the design of reinforced concrete columns to TCVN 5574:2018. Within Excel, the VBA macro opens or attaches to the analysis model, queries each column for axial force (P or N), biaxial moments (Mx, My), and shear forces (Qx, Qy) and stores the results directly in worksheet arrays. TCVN 5574-2018 design equations are implemented as VBA functions that immediately compute required bar areas and verify capacity. Because internal forces flow straight from the model to the spreadsheet, manual copy-and-paste steps are eliminated; a single macro refresh updates the entire building whenever the analysis changes. Trial projects show that the automated run completes faster than manual method and reproduces hand-checked results, demonstrating both numerical reliability and substantial time savings. The same modular architecture can be expanded to beams, slabs, or foundations, supporting wider digital transformation in Vietnamese structural practice.

2.1. Integration of Excel VBA with the CSi API

In the conventional practice, analysis results from ETABS were exported to an external Microsoft Access database (.mdb). The design team then opened Excel and either linked or imported, the relevant tables before executing the reinforcement calculations—sometimes through secondary VBA scripts. Each design revision repeated this sequence: regenerate the .mdb, refresh the spreadsheet links, and re-run the computations. The additional file layer introduced version-control risk, increased the possibility of mismatched data, and extended update time, particularly on projects with frequent load-case adjustments.

The CSi API (for ETABS or SAP2000) is exposed as a COM library that Excel's VBA can invoke, enabling the spreadsheet to drive the structural model and retrieve results automatically. In practice, the VBA code is created or attached to the CSI application object, obtaining a handle for the SapModel representing the current structure. In this study, the main VBA CSi API command of SapModel.Results.FrameForce calls for each selected column to return its internal forces as axial forces, shear forces and bending moment components under specified load cases. Then, these values are directly written into the Excel workbook using VBA Excel codes. Because this is done programmatically, all relevant columns and load combinations are processed without manual copying. In summary, the integration proceeds in key steps: initialize the API interface, retrieve internal forces for each column, and transfer those results into Excel. The retrieved forces thus reflect the latest analysis model automatically, and are ready for the subsequent TCVN 5574:2018 design checks without any manual data entry.

As shown in Table 1, a typical sequence begins with the command Cm1 to confirm the currently selected members. This command allows the user or engineer to control the selected members they want to design. Subsequent calls list the active load combinations (Cm2), cross-section dimensions (Cm3), internal forces, including Axial, moment and shear forces (Cm4), and element labels (Cm5). Additional commands allow Excel to change analysis settings directly to the Etabs model, without leaving the spreadsheet—for example, assigning the number output stations (Cm6), analysing the entire model (Cm7), and getting the stories's information, which includes the stories height or column height (Cm8). Implementation details and example code for the VBA–CSi API functions are provided on CSI's official website [16].

Table 1. The VBA CSi API command using for automated RC column design Excel sheet.

VBA CSi API Command	Notation
SapModel.SelectObj.GetSelected	Cm1
RespCombo.GetNameList	Cm2
PropFrame.GetRectangle	Cm3
Results.FrameForce	Cm4
FrameObj.GetLabelFromName	Cm5
FrameObj.SetOutputStations	Cm6
Analyze.RunAnalysis	Cm7
SapModel.Story.GetStories	Cm8

2.2. Reinforced Concrete Column Design Algorithm

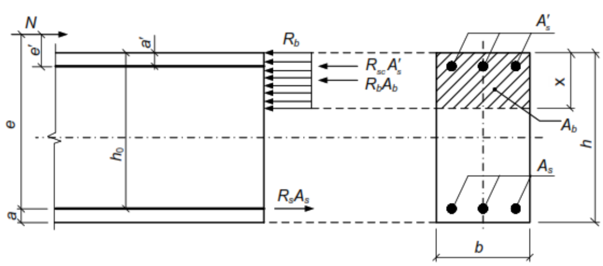


Figure 2. Internal Force and Stress Diagrams in the Cross Section [1].

Axial-Flexural capacity of an RC section is based on nonlinear sectional analysis, assuming Bernoulli's hypothesis (plane sections remain plane) and strain compatibility between concrete and steel. Under the increasing bending forces, concrete acts as a nonlinear material behaviour (cracking under tension and a parabolic/rectangular compression stress block). Meanwhile, the longitudinal bars are elastic and perfectly plastic. As shown in Figure 2, the design assumptions typically include: linear strain variation across the depth, neglect of concrete tensile resistance, and a maximum concrete compressive strain (e.g. 0.003 in ACI318-19 [17] code and TCVN 5574:2018 code). Under these assumptions, the internal compressive force in concrete (modelled by an equivalent rectangular stress block of intensity 0.85 f′c) is equilibrated by the tensile force in the reinforcement, and the resulting Nominal moment capacity Mn is found by taking moments about the neutral axis. The sectional analysis procedure is encoded in major standards ACI 318-19, EN 1992-1-1 [18] and TCVN 5574:2018.

According to the sectional analysis method illustrated in Figure 2, TCVN 5574:2018 stipulates that the strength of a rectangular cross-section subjected to eccentric compression is evaluated according to the condition given in Eq. (1).

$$Ne \le R_b bx(h_o - 0.5x) + R_{sc}A_s^{'}(h_o - a') \qquad \text{Eq. 1}$$

Where N is axial force; e denotes the eccentricity, measured from the line of action of the axial force; R_b is the specified compressive strength of concrete, x is the depth of compression fiber, h_o is the effective height of cross-section, R_{sc} is the specified compressive strength of compressive bars, $A_s^{'}$is the total area of compressive bars, and a' is the concrete cover in compression-zone. All symbols must be expressed using a single, consistent system of units — for example, the SI system.

Based on the limited value of relative height ξ_R, the depth of compression fiber, x, shall be determined as the following equation.

When $x/h_o \le \xi_R$

$$x = \frac{N + R_s A_s - R_{sc}A_s^{'}}{R_b b} \qquad \text{Eq. 2}$$

When $x/h_o \ge \xi_R$

$$x = \frac{N + R_s A_s \frac{1+\xi_R}{1-\xi_R} - R_{sc}A_s^{'}}{R_b b + \frac{2R_s A_s}{h_o(1-\xi_R)}} \qquad \text{Eq. 3}$$

Where b is the width of the cross-section, as shown in Figure 2.

TCVN 5574:2018 prescribes an iterative procedure for determining the tensile longitudinal bar area A_s and compressive-steel area A_s' in a column subjected to eccentric compression. As and As′ trial values are chosen and checked with Equation 1. If equation 1 is not satisfied, the designer must choose other values of A_s, and A_s', then repeat the check until the inequality is satisfied; once the check passes, the section can resist the axial force P acting at eccentricity e. Because manual execution of this iterative routine is time-consuming, the task is automated with an Excel VBA macro. The algorithm sweeps the reinforcement ratio μ from minimum to maximum permissible limits; if no value fulfils Equation 1, the program signals that a larger cross-section is required. In this study, the reinforcement of reinforced concrete columns is proposed to be arranged symmetrically, $A_s = A_s'$. This is the method commonly used in design problems in Vietnam. Figure 3 presents a concise procedure flowchart, while elementary formulas are omitted for brevity.

Shear design for columns adopts the same VBA–CSi API workflow by Hoang et al. [19]. In TCVN 5574:2018, the capacity-check procedure—identical for reinforced-concrete beams and columns—is framed with an inclined-section model in which the internal shear resistance equilibrates the external shear force. That resistance comprises the concrete shear capacity, $Q_{b,1}$, plus the contribution of the transverse reinforcement, $Q_{sw,1}$, as shown in Equation 4. The step-by-step algorithm is summarised in Figure 4, while elementary formulas are omitted for brevity.

$$Q \le Q_{b,1} + Q_{sw,1} \qquad \text{Eq. 4}$$

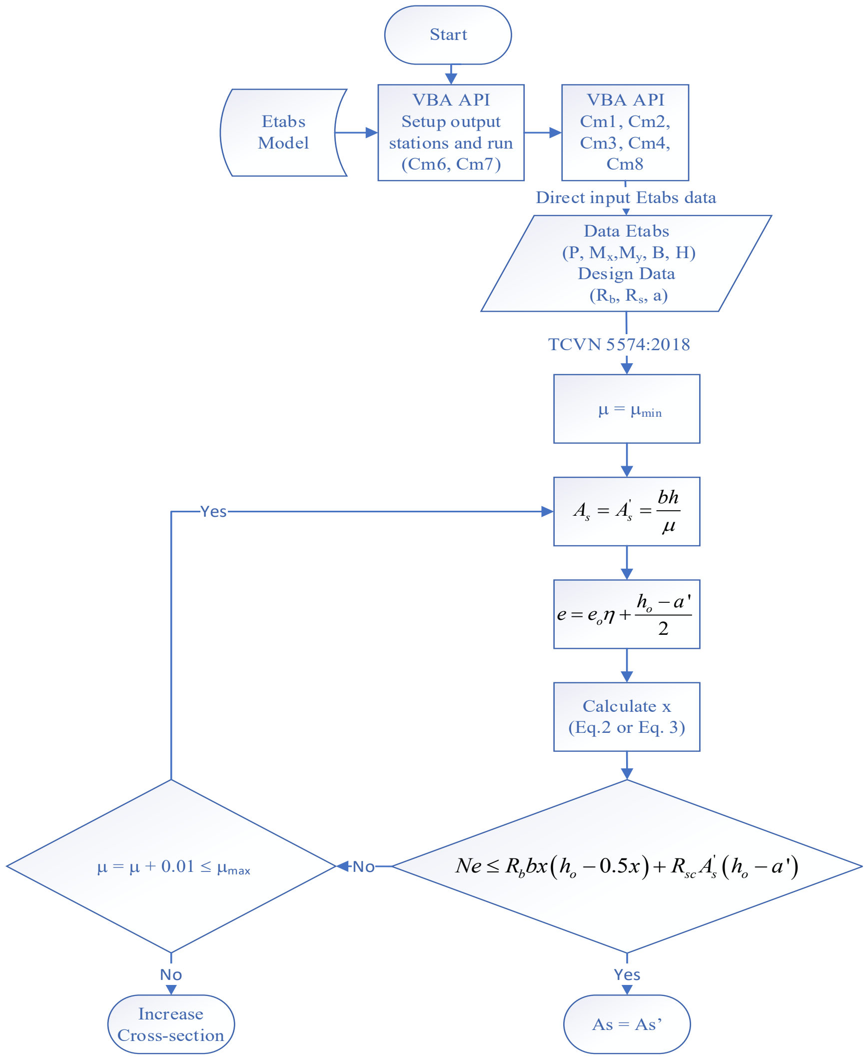


Figure 3. Flowchart for Designing the RC Columns in Axial-flexural Resistance.

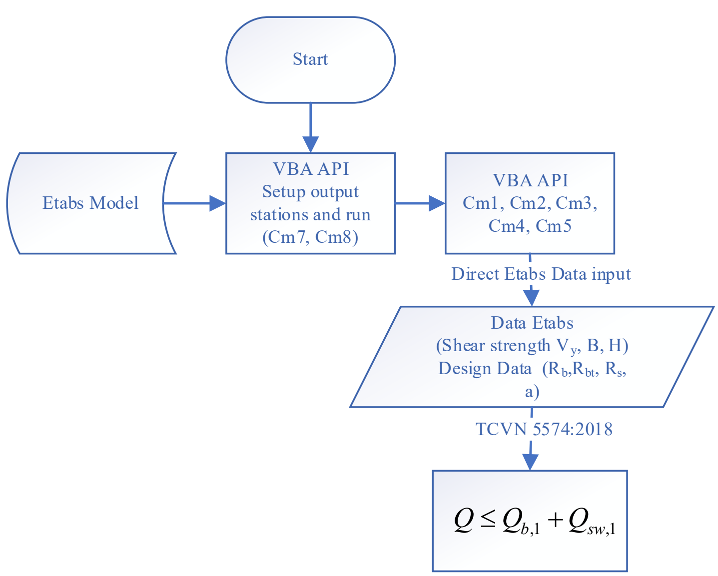


Figure 4. Flowchart for Designing the RC Columns in Shear resistance [19].

3. Verification and discussion

3.1. Verification

Figure 5 depicts the programmed Excel workbook, which contains two flexure and shear resistant design sheets. In the compression–flexure worksheet, two VBA layers work together. First, CSi API calls pull geometry and force data directly from the open ETABS model. Second, a short Excel-VBA routine handles the key design variable—the steel ratio μ. The routine cycles μ from a code-based minimum up to an upper limit of 4 %. The lower bound is calculated exactly as required in TCVN 5574:2018; the 4 % cap reflects values recommended in several other international standards. Designers may adjust the upper bound, but any revision must remain inside the limits set by the relevant national or international code.

To assess the spreadsheet's performance, a two-dimensional frame was analysed under self-weight and temporary load specified in TCVN 2737:2023 [20]. Five live-load cases and two wind-load cases were defined in the frame model, from which twenty-seven load combinations were constructed to capture all potentially critical load effects. The table 2 shows the load combinations based on TCVN 2737:2023 and Figure 5 shows the analysis results of 27^{th} load combination. All C3 column elements were selected for detailed evaluation. In the model, the specified strength is $R_b = 11.5$ MPa for concrete grade B15, while the adopted the transverse reinforcement grade CB240-T with $R_{sw} = 170$ Mpa, wich are defined with two-leg Ø8 mm hoops at 100 mm spacing for support zone and at 200 for middle zone of column height; and the specfied strength of $R_s = 260$ MPa is used for longitudinal bars of CB300-V grade.

Where TT represents the permanent (dead) load, HT1 is the full short-term temporary load, HT2 and HT3 are type-1 and type-2 alternate-span short-term temporary loads, HT4 and HT5 are type-1 and type-2 continuous-span short-term temporary loads, while GT and GP are wind loads blowing from left to right and from right to left, respectively. All loads have added the safe factor, which follows the TCVN 2737:2023 code.

For each column, axial force, bending moment, and shear were extracted and processed in the shee. On a laptop equipped with an 8th-generation Core i7 processor, 16 GB of RAM, and an 8 GB graphics card, the spreadsheet completes data import, processing, and design checks for five columns in about 21 seconds, either not counting the brief time needed to click the Excel buttons. The resulting bar sizes for bending and shear are summarised in Figure 6 and Figure 7. Figure 6 lists the governing results for column C3 in the load combination case of TH2. The axial compression P drops from $-2\,567$ kN at Story 1 to -195 kN at Story 5, and the bending moment about the 3-3 axis $M_{3\text{-}3}$ falls from -38.34 kN·m to 9.91 kN·m over the same height. Consequently, the required longitudinal steel area A_s decreases from 2.55 cm^2 to 0.88 cm^2. Throughout all floors, the steel ratio μ stays below 0.01 %, satisfying Equation 1 and the design steps shown in Figure 3. These figures confirm that gravity loads govern the design of column C3, while lateral effects are secondary. The initial column cross-section was deliberately generous, which is reflected in the transverse-reinforcement design: the preliminary layout uses Ø8 mm hoops at 100 mm spacing near the column ends and 150 mm in the mid-height zone, as illustrated in Figure 7. Because the VBA macro is linked to the CSi API, ETABS forces import straight into Excel, the μ-loop runs automatically, and the routine selects the largest code-compliant A_s without manual data transfer.

Meanwhile, manual evaluation (hand calculation) of the twenty-seven load combinations is time-intensive, while even a conventional Excel worksheet still requires a separate filtering step to isolate the most critical combinations before iterating on the steel-ratio factor μ. Even when Excel VBA performs iterative calculations of the steel-ratio factor μ, the absence of a direct CSi API link obliges engineers to export ETABS results manually or through an intermediate Access file and then import them into Excel. These repeated data transfers prolong the workflow, increase the risk of transcription errors, and must be repeated each time the structural model is modified, thereby reducing overall computational efficiency.

3.2. Discussion

By combining the VBA Excel and VBA CSi API in the spreadsheets, the work design can be redesigned for a single column or all columns in the model by simply changing the ETABS 'selected objects' filter. Direct integration allows for quick changes, selection, and retrieval of data from ETABS without requiring intermediate steps or manual copying and pasting of data. This setup is a step towards a fully digital workflow where analysis, design, and drawings stay updated together.

In addition, the spreadsheets embedded with VBA Excel and VBA CSi API make the work design routine into one smooth cycle. Instead of exporting ETABS results, importing them into a spreadsheet, and checking many trial bar areas (steel area ratio m), the macro pulls axial force, moments, and shear forces straight into Excel and automatically runs the TCVN 5574:2018 checks, removing every copy-and-paste step and the errors that may occur.

The macro also searches for the steel ratio μ on its own. It starts at the minimum value set by the code to the maximumn value of 4 %, the common limit for regular columns. Since the loop runs by computer, it may propose to the other maximum ratios, making it easier to find the benefit and safty, but these ratios have to be met the national or international codes.

On a standard laptop (i7-8750H, 16 GB RAM), the script designs five full-height columns in about 21 seconds; Meanwhile, the manual route takes several minutes. On a tall building with hundreds of columns and frequent load-case updates, the hours saved add up quickly and can shorten delivery dates or cut design costs.

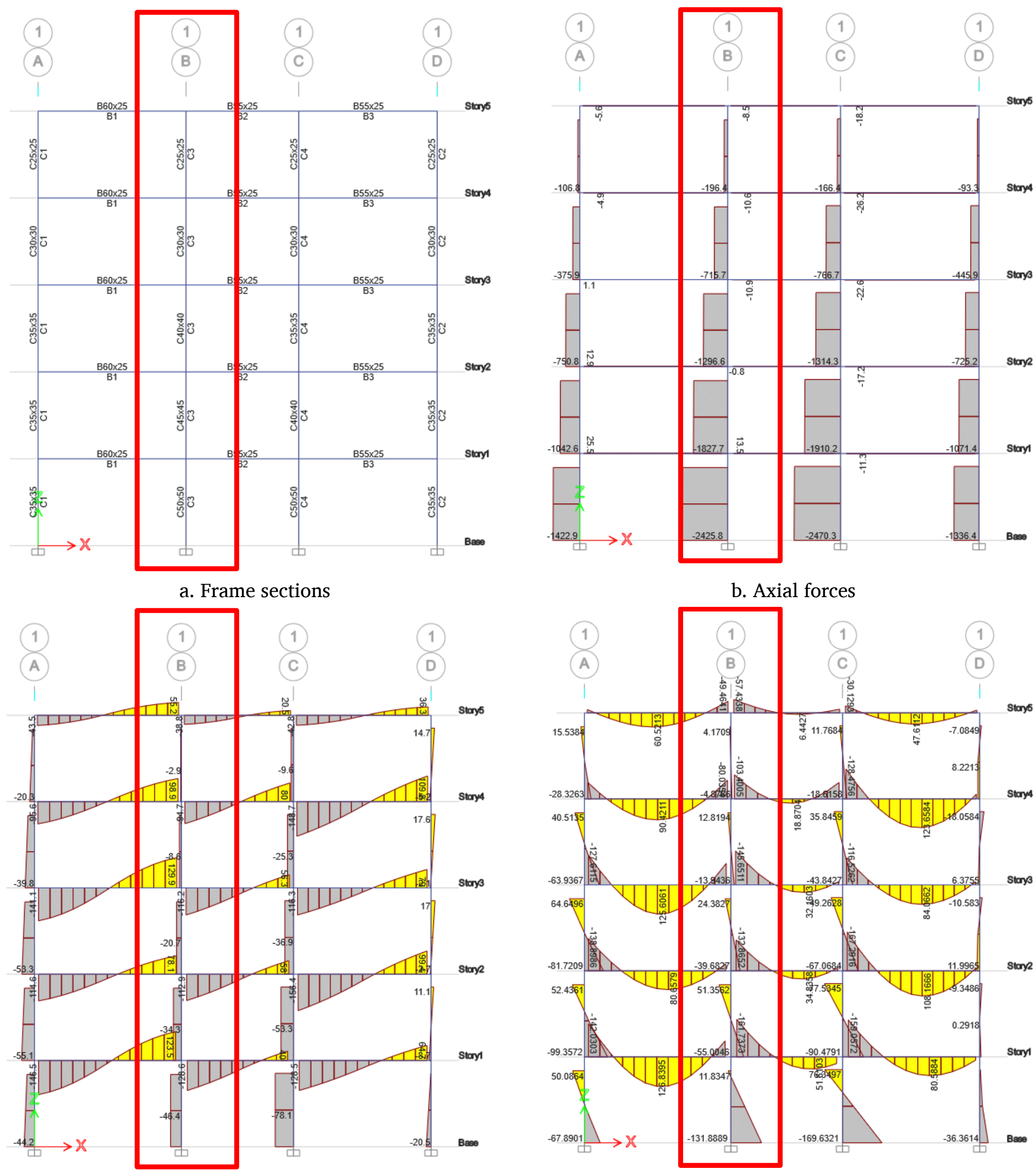
Because the tool is Excel VBA, any office that already uses ETABS and Microsoft Office can install it without extra licenses or special training. Open source code lets staff review, tweak, and expand the script as needed. In Vietnam's push toward digital construction, such low-cost, code-compliant tools help firms modernise now without waiting for future commercial software updates.

3.3. Limitations

Available documentation for the API is limited, and detailed examples cover only a few basic tasks. Easy, step-by-step examples for real design problems are hard to find and mostly exist in paywares like Dbim. So, programmers may struggle when they try to add complex features or fix odd error messages.

Because ETABS evolves continuously, the VBA code must be maintained whenever a new software release adds, renames, or removes API commands. Without such maintenance, the macro may fail or return incomplete results.

The usual maximum steel ratio is 4 %, which works for most ordinary reinforced concrete columns. However, some columns need a different limit—for example, boundary columns in high-earthquake zones or very slender columns that can buckle more easily. If you change the 4 % cap, the new limit must still match the rules of the relevant national or international code.



a. Frame sections

b. Axial forces

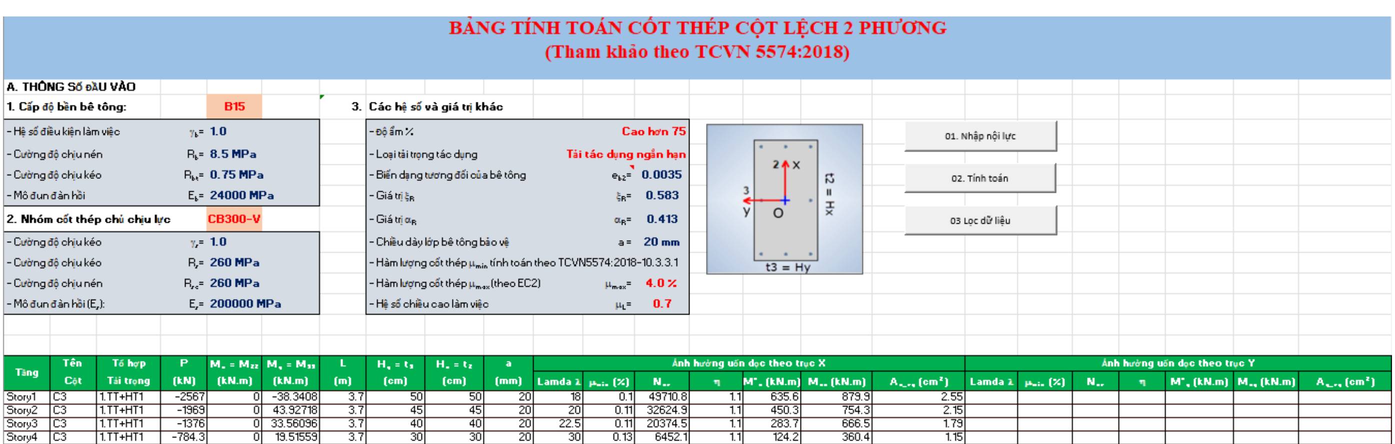
c. Moment diagrams (kN.m)

d. Shear diagrams (kN)

Figure 5. An example of an RC frame.

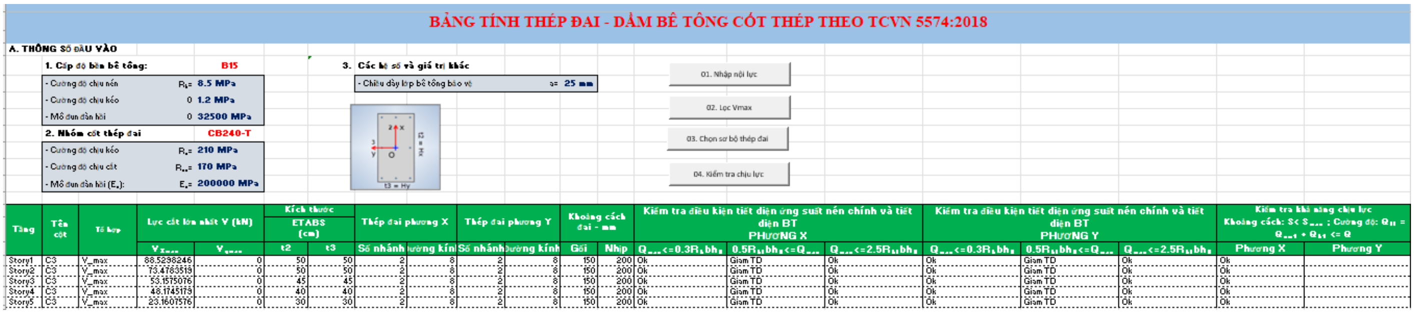
Table 2. The list of load combinations for example RC frames.

Load combination name	Combination type	Loads name and scale factor
TH1	Linear Add	TT + HT1
TH2	Linear Add	TT + HT2
TH3	Linear Add	TT + HT3
TH4	Linear Add	TT + HT4
TH5	Linear Add	TT + HT5
TH6	Linear Add	TT + GT
TH7	Linear Add	TT + GP
TH8	Linear Add	TT + HT1 + 0.9GT
TH9	Linear Add	TT + HT2 + 0.9GT
TH10	Linear Add	TT + HT3 + 0.9GT
TH11	Linear Add	TT + HT4 + 0.9GT
TH12	Linear Add	TT + HT5 + 0.9GT
TH13	Linear Add	TT + HT1 + 0.9GP
TH14	Linear Add	TT + HT2 + 0.9GP
TH15	Linear Add	TT + HT3 + 0.9GP
TH16	Linear Add	TT + HT4 + 0.9GP
TH17	Linear Add	TT + HT5 + 0.9GP
TH18	Linear Add	TT + 0.9HT1 + GT
TH19	Linear Add	TT + 0.9HT2 + GT
TH20	Linear Add	TT + 0.9HT3 + GT
TH21	Linear Add	TT + 0.9HT4 + GT
TH22	Linear Add	TT + 0.9HT5 + GT
TH23	Linear Add	TT + 0.9HT1 + GP
TH24	Linear Add	TT + 0.9HT2 + GP
TH25	Linear Add	TT + 0.9HT3 + GP
TH26	Linear Add	TT + 0.9HT4 + GP
TH27	Linear Add	TT + 0.9HT5 + GP



Tầng	Tên Cột	Tổ hợp Tải trọng	P (kN)	$M_x = M_{22}$ (kN.m)	$M_y = M_{33}$ (kN.m)	L (m)	$H_y = t_3$ (cm)	$H_x = t_2$ (cm)	a (mm)	Ảnh hưởng uốn dọc theo trục X: Lamda λ	μ_{min} (%)	N..	η	M^*_x (kN.m)	M.. (kN.m)	A.. (cm²)	Ảnh hưởng uốn dọc theo trục Y: Lamda λ	μ_{min} (%)	N..	η	M^*_y (kN.m)	M.. (kN.m)	A.. (cm²)
Story1	C3	1.TT+HT1	-2567	0	-38.3408	3.7	50	50	20	18	0.1	49710.8	1.1	635.6	879.9	2.55							
Story2	C3	1.TT+HT1	-1969	0	43.92718	3.7	45	45	20	20	0.11	32624.9	1.1	450.3	754.3	2.15							
Story3	C3	1.TT+HT1	-1376	0	33.56096	3.7	40	40	20	22.5	0.11	20374.5	1.1	283.7	666.5	1.79							
Story4	C3	1.TT+HT1	-784.3	0	19.51559	3.7	30	30	20	30	0.13	6452.1	1.1	124.2	360.4	1.15							
Story5	C3	1.TT+HT1	-194.6	0	9.909843	3.7	25	25	20	36	0.14	2786.2	1.1	31.1	396.3	0.88							

Figure 6. Calculation of longitudinal bar for all Columns C1.



BẢNG TÍNH THÉP ĐAI - DẦM BÊ TÔNG CỐT THÉP THEO TCVN 5574:2018

A. THÔNG SỐ ĐẦU VÀO

1. Cấp độ bền bê tông: B15
- Cường độ chịu nén R_b= 8.5 MPa
- Cường độ chịu kéo 0 1.2 MPa
- Mô đun đàn hồi 0 32500 MPa

2. Nhóm cốt thép đai CB240-T
- Cường độ chịu kéo R_s= 210 MPa
- Cường độ chịu cắt R_{sw}= 170 MPa
- Mô đun đàn hồi (E_s): E_s= 200000 MPa

3. Các hệ số và giá trị khác
- Chiều dày lớp bê tông bảo vệ a= 25 mm

01. Nhập nội lực
02. Lọc Vmax
03. Chọn sơ bộ thép đai
04. Kiểm tra chịu lực

Tầng	Tên cột	Tổ hợp	Lực cắt lớn nhất V (kN)		Kích thước ETABS (cm)		Thép đai phương X		Thép đai phương Y		Khoảng cách đai - mm		Kiểm tra điều kiện tiết diện ứng suất nén chính và tiết diện BT PHƯƠNG X			Kiểm tra điều kiện tiết diện ứng suất nén chính và tiết diện BT PHƯƠNG Y			Kiểm tra khả năng chịu lực Khoảng cách: S< S_{max} ; Cường độ: Q_{u} = Q_{sw} + Q_{b} <= Q	
			$V_{x,max}$	$V_{y,max}$	t2	t3	Số nhánh	Đường kính	Số nhánh	Đường kính	Gối	Nhịp	$Q_{max}<=0.3R_bbh_0$	$0.5R_{bt}bh_0<=Q_{max}$	$Q_{max}<=2.5R_{bt}bh_0$	$Q_{max}<=0.3R_bbh_0$	$0.5R_{bt}bh_0<=Q_{max}$	$Q_{max}<=2.5R_{bt}bh_0$	Phương X	Phương Y
Story1	C3	V_max	88.5298246	0	50	50	2	8	2	8	150	200	Ok	Giam TD	Ok	Ok	Giam TD	Ok	Ok	
Story2	C3	V_max	73.4763519	0	50	50	2	8	2	8	150	200	Ok	Giam TD	Ok	Ok	Giam TD	Ok	Ok	
Story3	C3	V_max	53.1575076	0	45	45	2	8	2	8	150	200	Ok	Giam TD	Ok	Ok	Giam TD	Ok	Ok	
Story4	C3	V_max	48.1745179	0	40	40	2	8	2	8	150	200	Ok	Giam TD	Ok	Ok	Giam TD	Ok	Ok	
Story5	C3	V_max	23.1607576	0	30	30	2	8	2	8	150	200	Ok	Giam TD	Ok	Ok	Giam TD	Ok	Ok	

Figure 7. Calculation of shear reinforcement for all Columns C1.

4. Conclusions

This research delivers a fully automated workflow for reinforced-concrete column design that bridges ETABS analysis with the Vietnamese code TCVN 5574:2018. By embedding direct CSi-API calls inside an Excel-VBA macro, axial force, biaxial moments, and shear from the live structural model are fed straight into code equations. At the same time, the steel-ratio variable μ is iterated from the code minimum to a 4 % ceiling until a safe, economical bar layout is found—all within a single execution cycle.

Benchmark tests on a standard laptop (8-core i7-8750H, 16 GB RAM) show that five full-height columns can be designed in roughly 21 seconds. Compared with the conventional export-to-spreadsheet sequence—requiring several minutes per revision—this automation cuts design time by an order of magnitude, eliminates copy-and-paste errors, and scales effortlessly from a single column to an entire building. Because the tool is written in plain VBA, any office already using ETABS can adopt, audit, and extend it without new licences or specialist training, thereby supporting Vietnam's broader move toward data-driven construction practice.

The current implementation is limited to ultimate-limit-state checks for axial–flexural and shear resistance; serviceability limits, crack control, and seismic confinement still need separate verification. API coverage remains partial, documentation sparse, and the VBA code must track future ETABS releases to stay functional.

Future work should (i) add serviceability and ductility modules, (ii) link the workbook to BIM databases for real-time 3-D reinforcement scheduling, and (iii) investigate cloud or Python wrappers that bypass Excel's row limits and enable batch processing. Despite these challenges, the present study confirms that open-API integration can yield immediate, measurable gains in speed, accuracy, and economic efficiency, offering a practical template for fully digital, standards-compliant concrete design in Vietnam and similar markets.

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