Article

Computer Programming for Analysis and Design of Edge Supported Rectangular Two-Way Solid Slab by Es En 1992-1-1:2015

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Abstract: This study's main target was to analyze and design rectangular edges supported two ways solid slabs by using ES EN 1992-1-1:2015. Slab design is often carried out either manually or with the use of design and analytic software. The researcher sees that some software cannot accept some countries' standard codes. For example, currently in Ethiopia analysis and design of two-way solid slab is done using readily available Excel sheet template. But working with this might have many problems, firstly the structure that is already analyzed by SAP or SAFE or any other international software application that uses international codes but which cannot design structure using ES EN 1992; for instant euro codes and designed by excel sheet can create failure and uneconomical analysis and design result. In this paper, the slab is designed and analyzed based on the chosen concrete grade, chosen reinforcement bar diameter, chosen steel grade for design and analysis of slabs calculations like load, moment, shear, and deflection checking using the moment coefficient method for analysis and design and Microsoft Visual Basic 2010 for coding. All input values are given by the International Standard units and are also used to represent output values. Using manual calculations delays time and mostly the result is not correct. But using this Computer program can increase computation accuracy and save time. The procedure the researcher followed is, first the manual calculation has been done and then SADSE2021 has been done. The result is that both are 99.9% identical, and the disadvantage of this method is that it cannot be used to determine the detailed drawing.

Keywords: Computer Program; User manual; Visual Basic; Solid Slab; and simply supported

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1. Introduction

Concrete is the most widely used construction material worldwide, and the most widely used material after water [23, 13]. This is due to the inherently useful characteristics of concrete: easily and globally obtainable raw materials, relative ease of processing and handling, and its ability to go from a fluid state, where it can fill a mold, to a solid state, where it can then bear a structural load [23]. It is a stone like substance produced when prepared carefully through the combination of cement, sand, gravel and water. The shape and size of the finished concrete can be set during the mixture of the elements by putting the mixture into a mold of desired dimensions [23, 19, and 10]. Concrete are usually reinforced with various other materials that have high tensile strength and the most abundantly used is reinforcement steel bars. This is called Reinforced Concrete. Reinforced concrete provides plenty of advantages to the users such as high compressive strength, high tensile strength, good fire and weather resistance, flexibility in molding them into countless shapes and sizes and low maintenance cost [12, 19, 22, and 23]. However, it is not without its disadvantages such as the requirement of mixing, casting and curing; all of which would affect the concrete strength, the high cost of the forms to mold the concrete and the its tensile strength is one-tenth of its compressive strength [12].

Slabs is one of the most widely used structural element as it forms the floors and roofs in order to support loads normal to the surface floor. The slabs can be simply supported or even continuously span over more than one supports [6, 9, 21]. Rectangular slabs that are supported only on two sides opposite of each other by walls or beams where the loads are uniformly distributed along the direction that is parallel to the supports [22, 14]. If the slab is square and is restrained similarly on all four sides, the load is distributed equally in both directions [6, 14]. There are two types of two-way solid slabs which are simply supported slab and restrained slab. Simply supported slabs have its all four sides deflect about both axes under loads where its corners would lift and curl up from the support [3].

2. Analysis and Design of Reinforcement Concrete

The design of a structure can be regarded as the process of choosing materials and elements proper for the structure. Depending on the requirements of the structure, design methods can be split into two categories which are: Ultimate Limit State and Serviceability Limit State. Ultimate Limit State covers the strength and stability of the structure under maximum design load in which the structure is expected to withstand. This also means that no part of the structure should encounter failure such as cracking, collapsing or buckling. Serviceability Limit State covers conditions in which specified service requirements are no longer met [23, 11].

Ultimately, reinforced concrete design to EC 2 has these following procedures; flexural design, shear design, deflection checking, cracking checking and detailing. Flexural design is based on bending moments acting on the structural element. It is the design of the specifications of the reinforcement steel bars such as diameter size and spacing to be used with concrete with regards to the loads. Shear design is the design of reinforcement steel bars to link each other in order to resist shear forces. Shear forces is transmitted through crack member via a combination of other un-cracked concrete in zone of compression, dowelling action of the flexural reinforcement and aggregates that interlock across the cracks of tension. Deflection checking requires that the span of the structural element is not high enough to lead to excessive deflection such as sagging of floors, partitions being crushed, buckling and so on. Cracking checking is to limit the width of individual cracks for durability and corrosion protection [23, 11, and 17].

Codes of practices and design standards such as ACI, Euro-code and British Standards are sets of technical specifications that act as a control of important details of design and construction [2]. These codes of practices have the sole purpose to produce sound and safe structures in order to protect the public from inadequately designed structures and constructions. For example the American Concrete Institute or ACI was founded in 1904 and acts as the leading authority and resource worldwide in the development and distribution of many design standards. Their main mission has always been the same which is to provide knowledge and information for the best use of concrete. ACI 318 Building Code Requirements for Structural Concrete is one of the most used design standards in America which is to provide minimum requirements for the design and construction of structural concrete under the requirements of a common code of building that is incorporated with it [4]. Whereas Euro-codes are a set of technical rules that are consensus-agreed developed by the European Committee of Standardization's for the structural design of works regarding construction mainly used in the European Union. The standards are published separately where each member has a number of parts. By March 2010, the Euro-codes were considered mandatory for European public works [7].

Software comprises the electronic instructions that govern the computer's functions [8,18]. A program consists of sequences of instructions to a computer, where it is written to perform specified task on a computer [18,4]. Unlike a program where a program is developed by individuals for their own personal use, software is much more complex. It is meant for multiple users and therefore has a good interface, designed systematically, thoroughly tested and implemented carefully. Software is most often very complex and too large for one person to create and develop single handedly [8, 15]. For example, given software that records names and addresses in a database. The program and database is considered a part of the software but the database is not a program [7, 4].

3. Research Methodology

Computer programming is the process of performing a particular computation (or more generally, accomplishing a specific computing result), usually by designing and building an executable computer program. Programming involves tasks such as analysis, generating algorithms, profiling algorithms' accuracy and resource consumption, and the implementation of algorithms (usually in a chosen programming language, commonly referred to as coding.

3.1. Methods:

The researcher used:

1. Microsoft visual basic 2010 for coding;
2. Microsoft Access 2010 For data base and;
3. The analysis of slab is conducted using limit state coefficient method and uses limit state method

3.2. Procedures

The researcher follows certain steps and procedures to develop the program. Those are:

1. The coding of the application in Microsoft Visual Basic 2010 is completed.;
2. Determine the thickness of the slab, in step with the procedures provided, and Check the kinds of Slab. The ratio of longer span to shorter span is equal to or greater than 2, considered a one-way slab. In a two-way slab, the ratio of longer span to shorter span is a smaller amount than 2 [7];
3. Calculation of Nominal cover, effective depth, and effective span: The deflection of the slab will be kept in check if the ratios of effective span to the effective depth of one-way slabs are obsessed from the provisions in ES EN 1992-1-1:2015. Supported ES EN 1992-1-1:2015: For Mild exposure = 20 mm,

For Moderate exposure = 30 mm, Effective depth = depth of slab - clear cover - 1/2 diameter of bar, The Effective span of the slab shall be lesser than the 2, L = clear span + d (effective depth). L = Centre to center distance between the support [22,14,15,21];

4. Calculate the factored loads and Determine moment coefficients;
5. Calculation of shear force and bending moments: the entire factored (design) loads are to be determined by adding the estimated loading of the slab, load of the ground finish, given or assumed live loads, etc. ES EN 1992-1-1:2015 after multiplying each of them with the respective partial safety factors. Loading values are taken from the Code ES EN 1992-1-1:2015. Thereafter, the planning positive and negative bending moments and shear forces are to be determined using the respective coefficients given in Tables 12 and 13 of ES EN 1992-1-1:2015;
6. Calculating the steel's area and the spacing between its reinforcing bars;

$$Mu = 0.87fy.Ast.d[1 - \frac{((Ast).(fy))}{(fck)(bd)}$$

7. Reinforcement spacing equals ((ast)/ (Ast)) * 1000 Where d is the diameter of the steel bars and ast is d2 /4;
8. Check for shear: For the safety of the given slab, design shear stress must be higher than nominal shear stress. v=Vu/(b*d) where d = effective depth, v = factored shear, and v = nominal shear stress;

The design shear value and the reinforcing Percent can be calculated using the code ES EN 1992-1-1:2015. The percentage of steel reinforcement is equal to Astprov*1000/Sprov. The steel portion of the given tension zone will be designated as Astprov. Sprov is the defined bar spacing in the tension zone. Design shear should be higher than the nominal shear value to assume that a slab section is secure.
For Deflection, check: max (l/d) > real (l/d), If the predicament mentioned is true Slab is resistant to deflection. (l/d) max: l=length in shorter span, d=effective depth, taken from the code ES EN 1992-1-1:2015.

3. Results and Discussion

3.1. Results: Introduction

Software comprises the electronic instructions that govern the computer's functions. A program consists of sequences of instructions to a computer, where it is written to perform specified task on a computer [7, 15]. Unlike a program where a program is developed by individuals for their own personal use, software is much more complex. It is meant for multiple users and therefore has a good interface, designed systematically, thoroughly tested and implemented carefully. Software is most often very complex and too large for one person to create and develop single handedly [4, 15, and 18]. For example, given software that records names and addresses in a database. The program and database is considered a part of the software but the database is not a program [18]. In this paper the researcher developed computer program which used to provide an easy interface for users to use and input values to the program which will carry out the calculations in a short amount of time and successfully allow the program to carry out calculations for the analysis of reinforced concrete design for two-way restrained slabs.

3.2. System Analysis and Design for Structural Elements/SADSE2021/

SADSE2021 is Computer programming that is developed for "System Analysis and Design of Structural Elements". In this Research the Part of SADSE2021 presented here is only SADSE2021 for Two Way Solid Slab only. The Program is developed using Microsoft Visual Basic 2010. Here in this research paper researcher uses visual basics for Calculations as described below. Having Microsoft Visual Basic 2010 on your desktop or PC; Visual basic allows users to perform any functions related to slab analysis and design by using the Moment Coefficient method. Steps to create a Microsoft Visual Basic 2010 project SADSE2021 include:

1. Open Microsoft Visual Basic 2010 (Using Microsoft Visual Studio 2010).;
2. Click the File menu, select File → new project;
3. Select "Windows Forms Application" in the pop-up New Project window and name the project.
4. Click File menu → Save All.

Then, once the program is finished in its programming and coding, the program will:

1. Able to be executed with any computer that has Microsoft Basic installed and its requirements;
2. Read inputs given such as Characteristic Actions;
3. Characteristic Strength of concrete and steel;
4. length and width of slab;
5. nominal cover;
6. slab thickness;
7. Slab Position Case;
8. Characteristic Strength of concrete and steel;

 doi:10.20944/preprints202208.0282.v2

Once inputs are correctly added clicking "Calculate" button will begin the calculation process and analyze the Two-Way Restrained Slab, Calculations will not be shown on-screen but it will give the answers on the screen for the following:

1. Area of the slab, A in mm2;
2. Design action, n in kN/m2;
3. Ratio of Ly/Lx, case;
4. Bending moment coefficients for short span sx and sy;
5. Bending moments: Msx1, Msx2, Msy1 and Msy2 in kN/mm2;
6. Diameter of bar in mm, Fctm in kN/mm2;
7. Effective depths, dx and dy in mm;
8. Minimum and maximum reinforcement area in mm2;
9. Areas of reinforcements for long spans and short spans with their respective mid spans and support, As in mm2/m2;
10. Values of k and z for the calculation of area of reinforcement,;
11. Design shear forces: Vsx1, Vsx2, Vsy1 and Vsy2;
12. Maximum shear force, Ved;
13. Design Shear Resistance, Vrd,c;
14. Diameter of bar in mm, Fctm in kN/mm2;
15. Minimum Shear Force, Vmin;
16. Maximum Bar Spacing for Main and Secondary Bars;

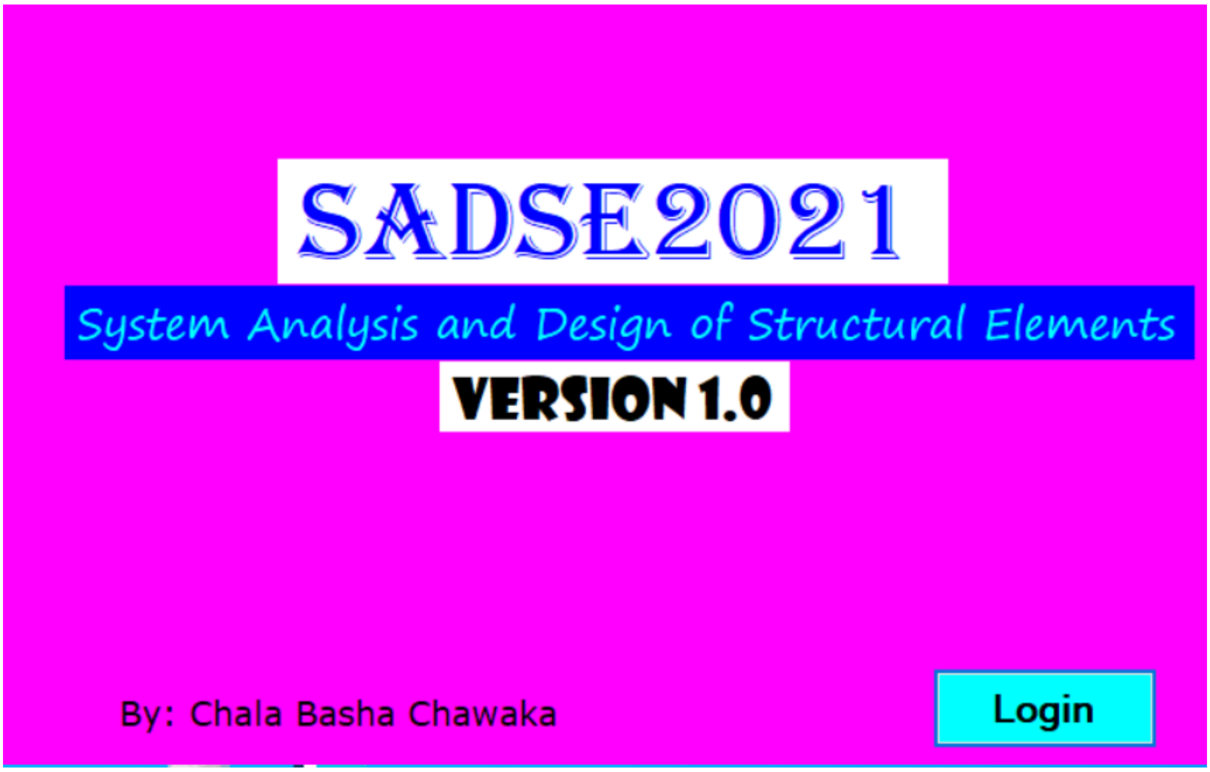

Figure 1 Screen of SADSE2021

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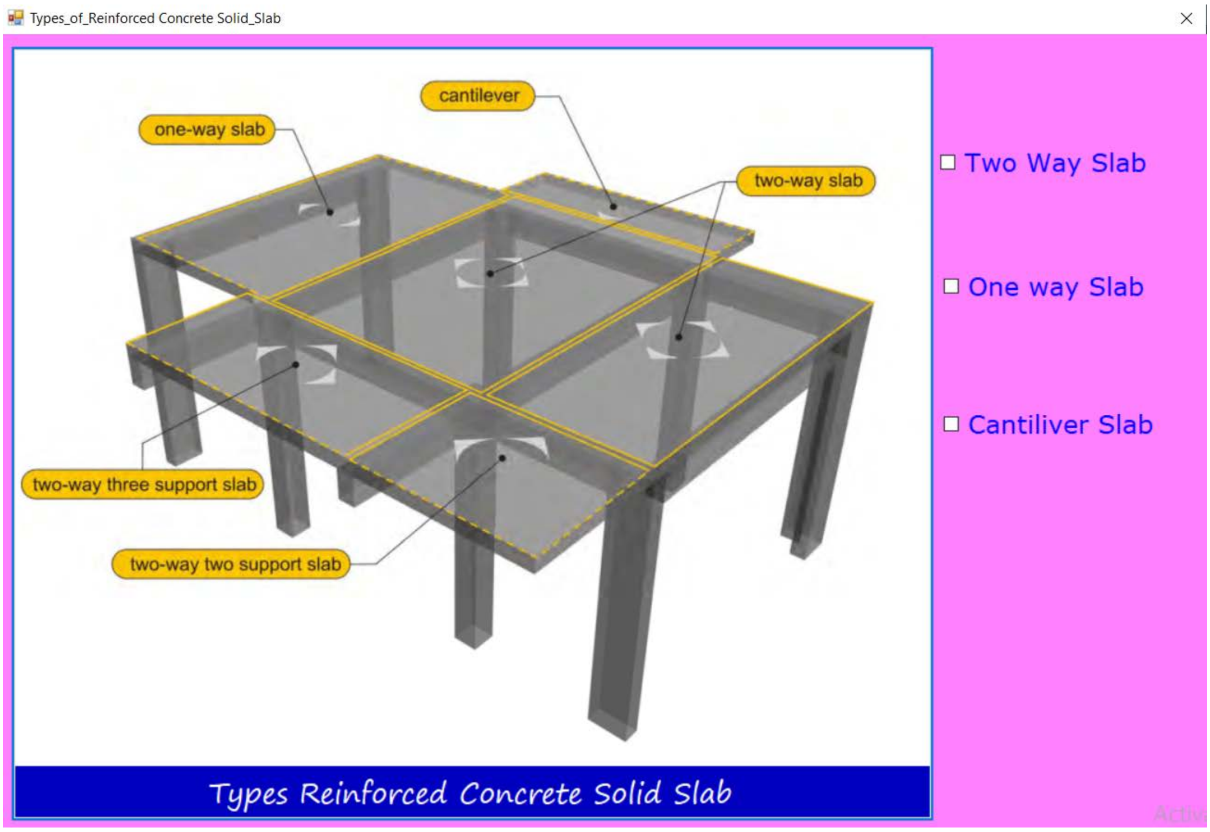

Figure 2 Screens for Selection of Types of RC Solid Slab

Table 1 Variables and Description

Abbreviation	Variables	Description
Fk	Characteristic value of an action	Value assigned to a basic variable, an action or a resistance from which the design value can be found by the application of a partial factor
Gk	Characteristic permanent action	Action whose variation in magnitude is despicable over the time, or whose variation is monotonous until a determined limit value is reached.
fc	Compressive strength of concrete	The Strength of hardened concrete measured by the compression test
fcd	Design value of concrete compressive strength	A coefficient taking account of long-term effects on the compressive strength.
fck	Characteristic compressive cylinder strength of concrete at 28 days	Characteristic compressive strength of 150 mm size cubes tested at 28 days
fcm	Mean value of concrete cylinder compressive strength	Measure of the concrete's ability to resist loads which tend to compress it.
fctk	Characteristic axial tensile strength of concrete	The maximum stress that a material can bear before breaking when it is allowed to be stretched or pulled
fctm	Mean value of axial tensile strength of concrete	Mean value of axial tensile strength of concrete at 28 days.
fy	Yield strength of reinforcement	An indication of maximum stress that can be developed in a material without causing plastic deformation
fyd	Design yield strength of reinforcement	the ultimate tensile strength of any bar shall be greater than ...
fyk	Characteristic yield strength of reinforcement	It should satisfy basic characteristics such as yield strength.

or l or L	Length; Span	The distance measured by a human hand, from the tip of the thumb to the tip of the little finger.

3.3. Discussion: Numerical Examples

Design the reinforcement for a simply supported slab 200 mm thick and spanning in two directions. The effective span in each direction is 4.5 m and 6.3 m and the slab supports a live load of 10kN/m2. The characteristic material strengths are fc = 30 N/mm2 and fy = 460 N/mm2.

Solution 1 (Using SADSE 2021)

Figure 3 Material Property of Concrete insertion page

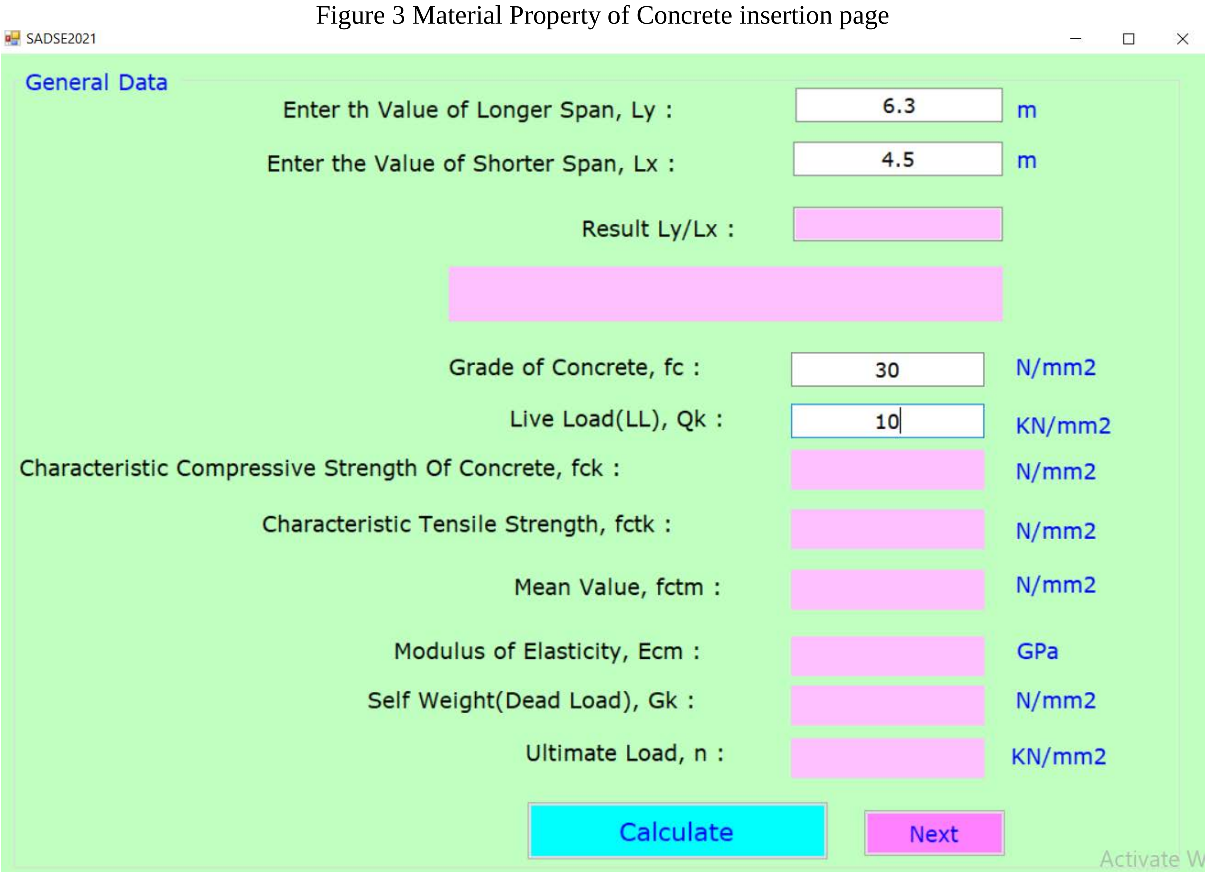

Figure 4 Material Property of Concrete

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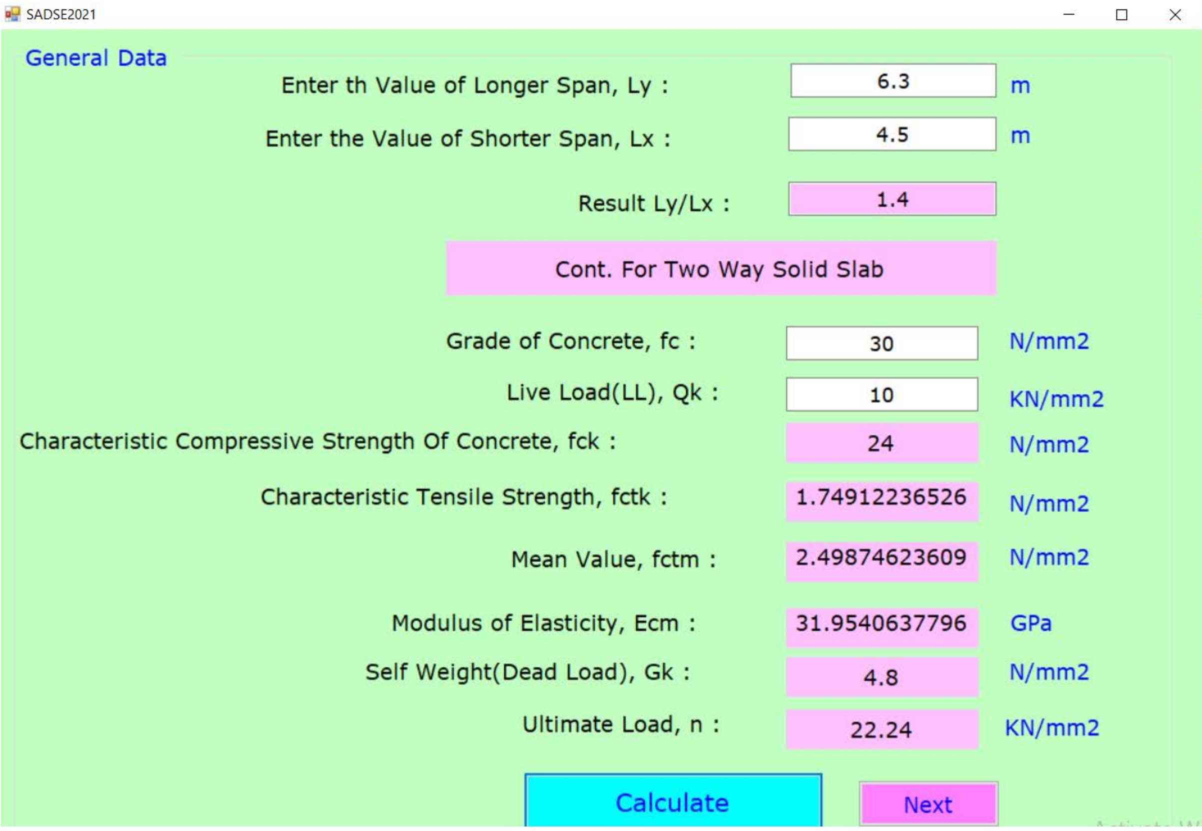

Figure 5 Material Property of Concrete Result

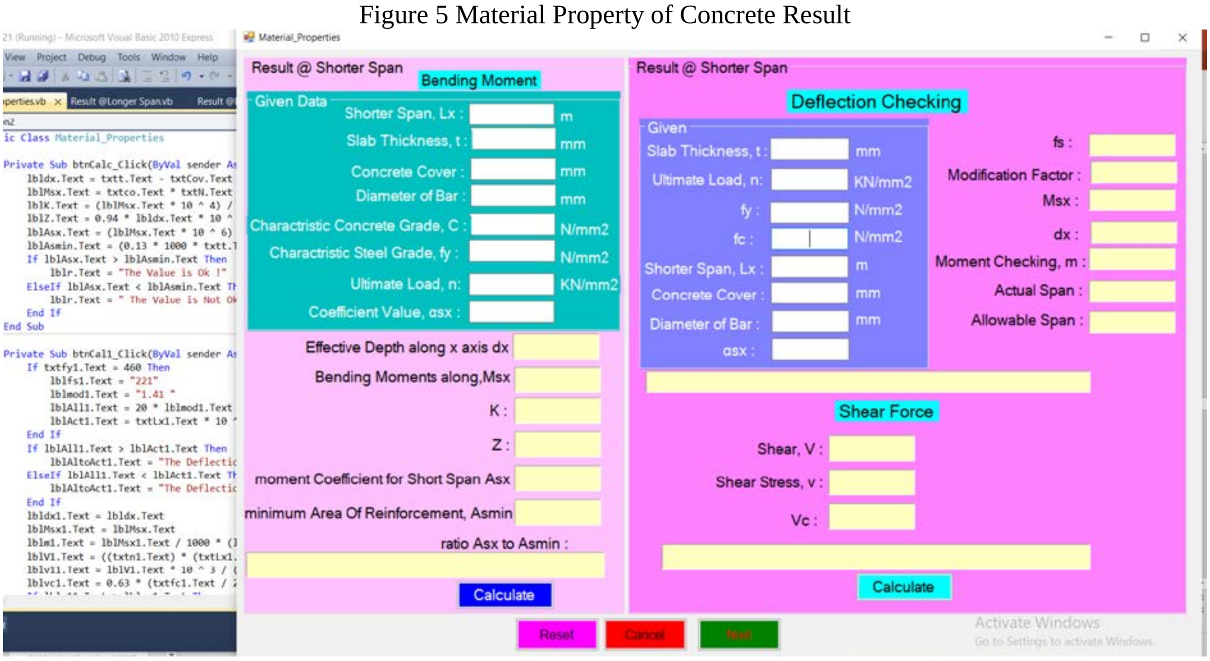

Figure 6 Screens @ Short Span

Figure 7 Screen to input data @ Short Span

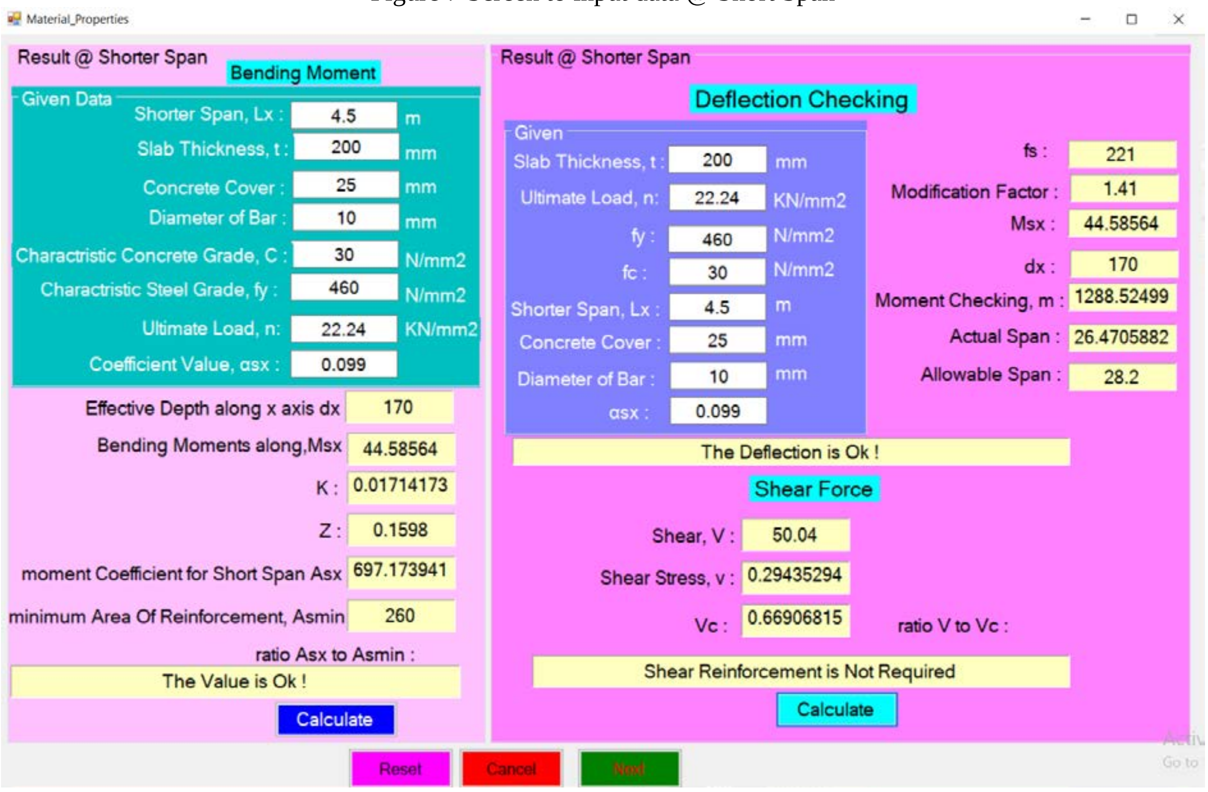

Figure 8 Result for the input data @ Short Span

Figure 9 Screens @ Long Span

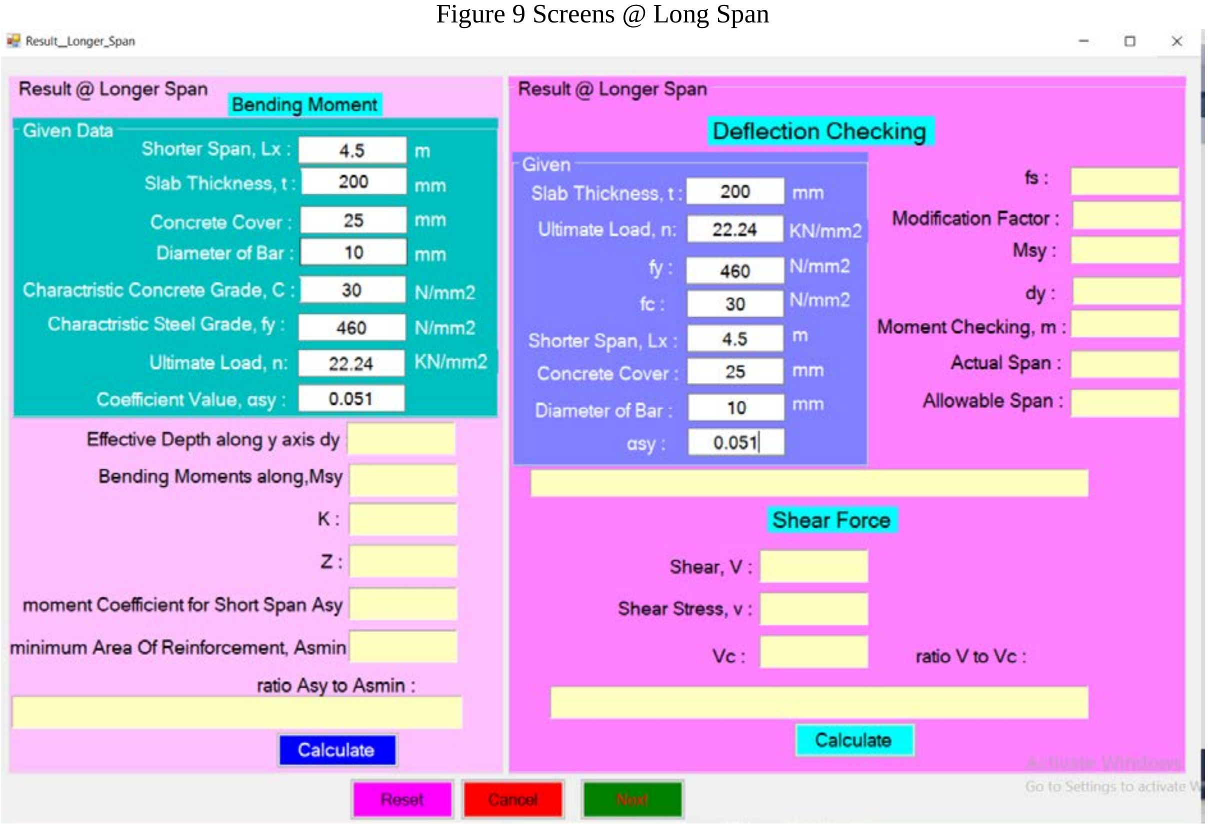

Figure 10 Input data @ Long Span

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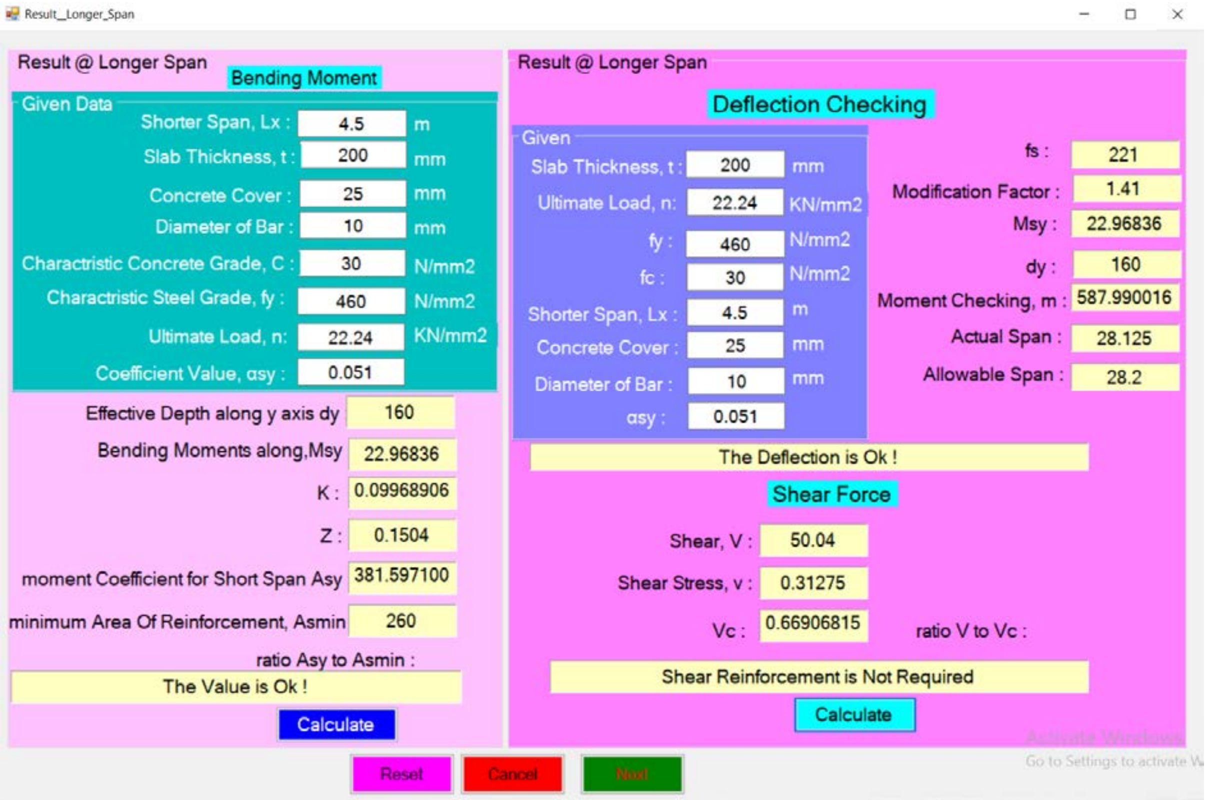

Figure 11 Results @ Long Span

Solution 2 Using Manual Calculation

$\frac{ly}{lx} = \frac{6.3}{4.5} = 1.4 < 2 \rightarrow$ Two – way slab, *From Table 3.14, α_{sx} = 0.099 and α_{sy} = 0.051.*

Self-weight of slab = 0.2 x 24 x 10^3 = 4.8 KN/m^2

Ultimate load, *n* = $1.3G_k + 1.6Q_k$

n = (1.3 x 4.8) + (1.6 x10) = 22.24kN/m^2 = **22.24 KN/m/m width**

Short Span

1) Bending

From Table 3.4, ES EN 1992-1-1:2015, mild exposure conditions, cover, *c* = 25 mm. Assume Ø bar = 10mm.

$d_x = h - c - Ø/2 = 200 - 25 - 5 = 170$ mm.

$m_{sx} = \alpha_{sx} n l_x^2$ = 0.099(22.24) $(4.5)^2$ = 44.97 KN.m/m

$K = \frac{M}{f cubd^2} = \frac{45.5 \; x \; 106}{30(1000)\;(170)2} = 0.017 < 0.156$

$z = d\{0.5 + \sqrt{(0.25 - K/0.9)}\} = d\{0.5 + \sqrt{(0.25 - 0.015/0.9)}\} = 0.94 < 0.95d$, so take $z = 0.94d$

$A_{sx} = m_{sx} / 0.87 f_y z$ = 44.58 x10^6 / (0.87x 460) (0.94x170) = 697.17 mm^2/ m

Checking A_{smin}, from Table 3.27 ES EN 1992-1-1:2015, f_y = 460 N/mm^2

A_{smin} = *0.13bh* / 100 = 0.13(1000 x 200) / 100 = 260 mm^2/ m $A_{sx} > A_{smin} \rightarrow$ ok

Provide T10 bars at 100 mm Centre, A_s = 786 mm^2/m

2) Deflection Checking

$\frac{M}{bd^2} = \frac{45.5 \; x \; 106}{(1000)\;(170)2}$ =1.57

From Table 3.11 ES EN 1992-1-1:2015, for f_s = 221 N/mm^2 the span-effective depth modification factor = 1.41. Therefore;

Allowable span / d > Actual span / d

20 x 1.41 > 4500 / 170

28.2 > 26.5 → ok

3) Shear

Shear, V = *WL* / 2 = (22.72 x 4.5) / 2 = 50.04 kN

Shear stress, *v* = *V / bd* = 50.04 x 10^3/ (1000 x 170) = 0.29 N/mm^2 < 0.8 $\sqrt{f_{cu}}$

From Table 3.9, ES EN 1992-1-1:2015,

$100A_s / bd$ = 100 x 786 / 1000 x 170 = 0.46

So, v_c = 0.63 x $(30/25)^{1/3}$ = 0.67 N/mm^2,

$v < v_c$, so no shear reinforcement is required.

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Long Span

1) Bending

From Table 3.4 ES EN 1992-1-1:2015, mild exposure conditions, cover, c = 25 mm. Assume Ø bar = 10mm.

$d_y = h - c - Ø/2 = 200 - 25 - 10 - 5 = 160$ mm.

$m_{sy} = \alpha_{sy} n l_x^2 = 0.051(22.72)(4.5)^2 = 22.97$ kNm/m

$K = \frac{M}{fcubd^2} = \frac{45.5 \times 106}{30(1000)(160)2} = 0.099 < 0.156$

$z = d\{0.5 + \sqrt{(0.25 - K/0.9)}\} = d\{0.5 + \sqrt{(0.25 - 0.099/0.9)}\} = 0.156 > 0.95d$, so take z = 0.95$d$

$A_{sy} = m_{sy} / 0.87 f_y z = 22.97 \times 10^6 / (0.87 \times 460)(0.95 \times 160) = 487.59$ mm^2/ m

Checking A_{smin}, from ES EN 1992-1-1:2015, f_y = 460 N/mm^2

$A_{smin} = 0.13bh / 100 = 0.13(1000 \times 200) / 100 = 260$ mm^2/ m

$A_{sx} > A_{smin} \rightarrow$ ok

Provide T10 bars at 200 mm center, A_s = 393 mm^2/m

2) Checking for Transverse Steel

From Table 3.27, f_y = 460 N/mm^2

$100As / bh = 100(393) / 1000 \times 200$

0.31 > 0.025 (A_{smin}) → ok

Comparison between Manual Calculation and SADSE2021

Criteria	Value in Manual Calculation		Value in SADSE2021		Value
	@Short	@Long	@Short	@Long	
Self-weight of slab	4.8	4.8	4.8	4.8	The Conclusion is that the Calculation Made by Manual and SADSE2021 is the same.
Ultimate load, n	22.24	22.24	22.24	22.24	
d_x and d_y	170	160	170	160	
m_{sx} and $m_{sx,}$	44.97	22.97	44.58	22.97	
K	0.017	0.099	0.171	0.09968	
z	0.15917	0.1536	0.1588	0.1504	
A_{sx}	697.17	487.59	697.17	487.59	
A_{smin}	260	260	260	260	
Ratio A_{sx} *to* A_{smin}	**Ok!**		OK!		
Allow/d	28.3	28.3	28.3	28.2	
Act/d	26.5	26.5	26.5	28.125	
$Defl_{Check}$	**Ok!**		**Ok!**		
V	50.4	50.4	50.4	50.4	
$V1$	0.29	0.31	0.29	0.31	
Vc	0.67	0.67	0.67	0.67	
$Shear_{Check}$	**Ok!**		**Ok!**		

3.4. Discussion

Computer Programming is essentially a process that comes from an original formulation for computing problems that turns into an executable program in which it will carry out the written formula. You can program and code a simple calculator to carry out simple calculations [4, 5]. There is much software that assists in the creation of new software such as Microsoft Small Basic, Microsoft Visual Basic and Java. Here in this study the researcher developed a computer program for the analysis and Design of Edge supported rectangular reinforced Concrete two-way solid slab that takes Ethiopian code of provisions and utilizes ES EN 1992-1-1:2015 using Microsoft Visual Basic 2010 for coding. This coding has done to overcome the delay in the manual calculations, to obtain the accuracy in the result calculations. As slab is an important element in the structural design aspect, it has to be designed very carefully. Also the unit conversion is not allowed in the coding, and all the dimensions are to be submitted in meters only. The Calculation Made by Manual and SADSE2021 is 99.9% the same and the drawback of this method is to determine the detail drawing.

4. Conclusions

As slab is an important element in the structural design aspect, it has to be designed very carefully. Here, the unit conversion is not allowed in the coding, and all the dimensions are to be submitted in meters only. The Calculation Made by Manual and SADSE2021 is 99.9% the same and the drawback of this method is to determine the detail drawing.

Funding: This research received no external funding.
Institutional review: Not applicable
Informed consent: Not applicable
Data availability: Not applicable.
Acknowledgments: First of all, I would like to thank God of Almighty; Whose Spirit is always guiding me with his council to the world of wisdom. In addition to that, I would like to express my heart full gratitude to a heroine who I always like to thank her with all my heart is my mother Mrs. Bashatu Mijena who has done a lot alone for me. She is the person behind the scene of my life and success. The other who I need to acknowledge is my University Wallaga University), College of Engineering and Technology and Department of Civil Engineering for their support in every direction.
Conflicts of interest: There is no potential source of conflict.

Abbreviations

The following abbreviations are used in this manuscript:

1. Abbreviations: The following abbreviations are used in this manuscript:

ACI	:American Concrete Institute	h	: Slab Thickness
As,min	:Minimum area of reinforcement	RC	: Reinforced Concrete
As,req	:Required area of reinforcement	m2	: Square meter
As,prov	:Provided area of reinforcement	MPa:	:Mega Pascal
b	:Width of slab	kN/mm2	: Kilo newton per square millimeter
bw	:Smallest width of the section in tensile area	n	:Total ultimate load per unit area
Cnom	:Nominal Cover	ned	: Design action
d	:Breadth of slab	Ly	: Length of longer span
dx, y	:Effective depth in x,y direction	Lx	: Length of shorter span
EN	:European Standards	Msx	: Maximum moment per unit width
fctm	Mean values of the axial tensile strength of concrete	Vsx	: Design shear force
fck	Characteristic strength of concrete		
fyk	Characteristic strength of steel		

2. Appendix

Coding by Visual Basic

```
Public Class SADSE2021
Dim Ly As Double
Dim Lx As Double
Dim r As Double
Dim fc As Integer
Dim fck As Double
Dim LL As Integer
Dim Gk As Double
Dim Qk As Double
Dim A, B, C As Double
Lx = TextBox2.Text
Ly = TextBox1.Text
fc = txtfcu.Text
LL = txtLL.Text
r = Ly / Lx
TextBox3.Text = r
If r >= 2 Then
lblType.Text = "Cont...For One Way Solid Slab"
lblfck.Text = (txtfcu.Text) / 1.25
lblGK.Text = 0.2 * lblfck.Text
lblN.Text = (1.3 * lblGK.Text) + (1.6 * txtLL.Text)
ElseIf r < 2 then
lblType.Text = "Cont. For Two Way Solid Slab"
lblfck.Text = (txtfcu.Text) / 1.25
lblfctm.Text = 0.3 * (lblfck.Text) ^ 0.667
lblfctk.Text = 0.7 * lblfctm.Text
lblEcm.Text = 9.5 * (lblfck.Text + 8) ^ 0.35
lblGK.Text = 0.2 * lblfck.Text
lblN.Text = (1.3 * lblGK.Text) + (1.6 * txtLL.Text)
Public Class Material_Properties
```

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```
lbldx.Text = txtt.Text - txtCov.Text - (txtBar.Text) / 2
lblMsx.Text = txtco.Text * txtN.Text * (txtLx.Text) ^ 2
lblK.Text = (lblMsx.Text * 10 ^ 6) / ((txtfc.Text * 1000) * (lbldx.Text)) ^ 2
lblZ.Text = 0.94 * lbldx.Text
lblAsx.Text = (lblMsx.Text * 10 ^ 6) / ((txtfy.Text * 0.87 * 0.94 * lbldx.Text))
lblAsmin.Text = (0.13 * 1000 * txtt.Text) / 100
If lblAsx.Text > lblAsmin.Text Then
lblr.Text = "The Value is Ok!”
ElseIf lblAsx.Text < lblAsmin.Text Then
lblr.Text = " The Value is Not Ok !"
If txtAll1.Text > txtAct1.Text Then
lblAltoAct.Text = "The Deflection is Ok!”
ElseIf txtAll1.Text < txtAct1.Text Then
lblAltoAct.Text = "The Deflection is Not Ok!”
lbldx1.Text = lbldx.Text
lblMsx1.Text = lblMsx.Text
lblm.Text = lblMsx1.Text / 1000 * (lbldx1.Text) ^ 2
lblV.Text = ((txtn1.Text) * (txtLx1.Text)) / 2
lblv1.Text = lblV.Text * 10 ^ 3 / (1000 * lbldx1.Text)
lblvc.Text = 0.63 * (txtfc1.Text / 25) ^ 0.33
If lblv1.Text > lblvc.Text Then
lblRatioVvc.Text = "Shear Reinforcement is required"
ElseIf lblv1.Text < lblvc.Text Then
lblRatioVvc.Text = "Shear Reinforcement is Not Required"
btnCalc3.Click
lbldy3.Text = (txtt3.Text - txtCov3.Text - (txtBar3.Text) / 2) - 10
lblMsy3.Text = txtco3.Text * txtN3.Text * (txtLx3.Text) ^ 2
lblK3.Text = (lblMsy3.Text * 10 ^ 6) / ((txtfc3.Text * 1000) * (lbldy3.Text)) ^ 2
lblZ3.Text = 0.94 * lbldy3.Text
lblAsy3.Text = (lblMsy3.Text * 10 ^ 6) / ((txtfy3.Text * 0.87 * 0.94 * lbldy3.Text))
lblAsmin3.Text = (0.13 * 1000 * txtt3.Text) / 100
If lblAsy3.Text > lblAsmin3.Text Then
lblr3.Text = "The Value is Ok!”
ElseIf lblAsy3.Text < lblAsmin3.Text Then
lblr3.Text = “The Value is Not Ok!”
If txtAll4.Text > txtAct4.Text Then
lblAltoAct4.Text = "The Deflection is Ok!”
ElseIf txtAll4.Text < txtAct4.Text Then
lblAltoAct4.Text = "The Deflection is Not Ok!”
lbldy4.Text = lbldy3.Text
lblMsy4.Text = lblMsy3.Text
ElseIf lblAllowperEff.Text < lblActualperEff.Text Then
lblAlltoAct.Text = "Deflection Check is Not Ok! Then Refer ES EN 1992-1-1:2015"
lblActualperEff.Text = (txtL.Text * 10 ^ 3) / lblEffd.Text
lblρ.Text = lblAsreq.Text / (1000 * lblEffd.Text)
lbloP.Text = (txtfc.Text * 0.5) / 1000
lblσs.Text = ((txtfy.Text) * (lblAsreq.Text) / (lblAsPro.Text) * ((lblSelfw.Text + (0.3 * txtL.Text)) / ((lblγG.Text)
* (lblSelfw.Text)) + (lblγQ.Text) * (txtLive.Text)) * (1 / lblδ.Text))
lblF3.Text = 310 / lblσs.Text
If lblRenfK.Text < lblkk.Text Then
lblComp.Text = "Compression Reinforcement is not Required!”
ElseIf lblRenfK.Text > lblkk.Text Then
lblComp.Text = "Compression Reinforcement is Required and Then Refer ES EN 1992-1-1:2015 For It."
lblSelfw.Text = ""                              lblEffd.Text = ""
lblActualperEff.Text = ""                       txtDiaBar.Text = ""
lblAllowperEff.Text = ""                        txtL.Text = ""
lblAsPro.Text = ""                              lblAsreq.Text = ""
txtCover.Text = ""                              lblComp.Text = ""
lbloP.Text = ""                                 lblρ.Text = ""
lblUlt.Text = ""                                lblMom.Text = ""
```

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```
lblRenfK.Text = ""
txtCover.Text = ""
txtL.Text = ""
txtt.Text = ""
txtfc.Focus()
End Sub
End Class
```

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