COMPUTER SIMULATION OF AIR-CONDITIONING SYSTEM DESIGN AND DUCTING ANALYSIS FOR PROFESSIONALS AND ENGINEERING STUDENTS

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Abstract

Air-conditioning system design and ducting analysis has over the years been an aspect of Engineering, which even though has developed greatly, yet it brings about very tedious tasks of analysis, low level of accuracy, and a lot of time input in carrying out its analysis manually. This work makes provision for the use of a software package, designed for ducting analysis. It has the capability of handling analysis for buildings having as much as nine (9) floors, with each floor having up to twenty (20) rooms. The report gives an account of the method used and the programming aspect of the package for ducting analysis. The thermal analysis of a building forms the basis for the equipment selection in terms of capacity of the cooling equipment, quantity of dehumidified air required and the type of system to be recommended. The estimated air quantity is then used in carrying out the analysis of the system. The package has been designed in such a way that results of analysis made could be printed out for use. Also, it can be easily used on any computer that has a floppy drive for its installation, and has been produced using Visual Basic 6.0. it would be very useful for professionals, as it can carry out analysis which might take hours to develop in few seconds, and also, can be used in higher institutions as teaching aid to INSTRUCT Engineering students.

Introduction

Air-conditioning is the science and practice of creating a controlled climate in indoor space. It thus implies the simultaneous control of temperature, humidity, air movement and quality of air in an indoor space. In general, it includes any treatment of air to desired quality level.

It is worth noting that good air-conditioning cannot be achieved without proper duct design or analysis. The function of a duct system is to transmit air from the air handling apparatus to the space to be conditioned. To fulfill this function in a practical manner, the system must be designed within prescribed limits of available space, friction loss, velocity, sound level, heat and leakage losses and gains. Deficiencies in a duct system can result in systems that operate incorrectly, or are expensive to own and operate. Poor air distribution can cause discomfort, poorly designed sections of ductwork can result in unbalanced systems, and faulty duct construction produces inadequate air flow rates at the terminal units.

Presently, air-conditioning provided in many buildings is far from perfect. The limitations are not due generally to lack of knowledge, but to 'cutting corners' in design, either for economic reasons or the tedious task of carrying out proper analysis. The air-conditioning system designer is concerned about workable designs, and much research has been carried out on system performance and human comfort. Considerable emphasis is now being placed on design standards, which ultimately will be reflected in rigorous specifications, if not regulations, as noted by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE). This has ultimately led to the development of a software package, which takes advantage of the computer age to carry out ducting analysis for buildings, making use of a simple method and laid down specifications with minimal error in computation.

Duct Design Method

The general procedure for designing any duct system is to keep the layout as simple as possible. The supply terminals are located to provide proper room air distribution, and ducts are laid out to connect these outlets. The ductwork should be laid out or located to avoid structural members and equipment.

The design of a low velocity supply air system may be accomplished using any of the various methods, which include Velocity Reduction, Equal Friction and Static Regain methods. These various methods result in different levels of accuracy, economy and use. The Equal Friction method is used in the design of the package, due to its advantages and high level of accuracy. The usual procedure is to select an initial velocity in the main duct near the fan, with sound level being the limiting factor. The friction

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chart is then used with the initial velocity and air quantity to determine the friction rate. This same friction loss is then maintained throughout the system, and the equivalent round duct diameter selected from the friction chart. In buildings where rectangular ducts are to be used, conversion tables in air-conditioning textbooks should be consulted in reading off values of the rectangular equivalent of round ducts. It should be noted that if rectangular duct sizes are determined directly from the duct area without using tables, the resulting duct sizes will be smaller, and velocity and friction loss will be greater for a given air quantity than the design values.

$$A = Q/V$$

or

$$Q = A.V$$

But $A = \Pi d_e 2/4$

$$\Rightarrow \quad d_e^2 = 4A/\Pi$$

or $\quad d_e = 2\sqrt{A/\Pi}$

where Q = total dehumidified air quantity (m^3/hr)
V = duct velocity (m/hr)
A = duct area (m^2)
de = duct diameter (m)

Design Of Software Package

The ducting analysis software was produced using Visual Basic 6.0, which is a programming language. The software has three (3) forms: one (1) for the introduction, and two (2) main forms for its operation. The first main form takes in the value of the total air quantity for a building for which ducting analysis is required and also the duct velocity, whose recommended value for various types of buildings can be got from air-conditioning textbooks. It normally ranges between 1200 and 2200 fpm for low velocity supply air systems. The duct area, and thus diameter of the main duct from the air handling unit/apparatus is thus calculated by the programme, using the equations above. After calculation of these values for the main duct, the user then proceeds to carry out the floor analysis. The package can adequately handle analysis for buildings having up to nine (9) floors at any particular time. Immediately the air quantity to each floor is fed in, the programme automatically calculates and shows the value of the duct diameter for each. After the floor analysis, the user could then print out the results, using 'Print Excel' command button and/or proceed to carry out the room analysis by clicking on the 'Room Analysis' command button. This takes the programme to the second form. Here, the user only inputs the floor number for which room analysis is required, and the values of that floor air quantity, its duct area and diameter are thus recalled. Thereafter, the user can proceed to the room analysis by feeding in the air quantity required in each room. As this is being done, the duct diameter is being calculated. The programme can handle room analysis for up to twenty (20) rooms at any particular time for a floor.

In generating results while using the package, values which relates the section area (%) to the air quantity (%) were used in the 'module' for the floor and room analysis. The S. I. Units is to be used when running the programme. Normally, the recommended *minimum* round duct diameter for ducting is 0.21m, or 210mm 8.4". Thus, calculated values which were less than this were automatically equated to 0.21m. Fig. 2 shows the flow chart for the software programme.

To validate the package, Kenneth Dike Library Extension, University of Ibadan was used as a case study. The building has three (3) floors, namely the basement, the lower ground floor and the upper ground floor. From the thermal analysis of the building, a dehumidified air quantity of 36,825m^3/hr

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(21,675cfm) was estimated. A duct velocity of 31,090m/hr (1700fpm) was selected from the range of recommended duct velocity for main ducts for libraries.

Results

Below is the analysis (obtained manually) for the Kenneth Dike Library Extension, using the section area (%) to the air quantity (%) relation rather than the friction chart:-

Mains:

Total air quantity, $Q = 36{,}825m^3/hr$
Duct velocity, $V = 32{,}090m/hr$
Duct area, $A = Q/V$
$= 36{,}825/31090$
$= 1.185m^2$
Duct diameter, $d_e = 2\sqrt{A/\Pi}$
$= 2\sqrt{1.185/3.142}$
$= 1.230m$

Floor:

Floor		**Air quantity**
1.	basement	$2{,}237m^3/hr$
2.	lower ground floor (LGF)	$18{,}729m^3/hr$
3.	upper ground floor (UGF)	$15{,}859m^3/hr$
	to size the floor ducts	

Table 1.1

Duct Section	**Air Qty(m^3/hr)**	**Cfm%**	**Duct Area %**	**Area (m^2)**	**Duct Size (m)**
Mains	36,825	100	100	1.185	1.23
Basement	2,237	6	10.5	0.124	0.40
LGF	18,729	51	59.0	0.699	0.94
UGF	15,859	43	51.0	0.604	0.88

Room:

A. Basement floor has one (1) space or room (Bindery)

Table 2.1

Duct Section	**Air Qty(m^3/hr)**	**Cfm%**	**Duct Area %**	**Area (m^2)**	**Duct Size (m)**
Basement (Bindery)	2,237	100	100	0.124	0.40

B. Lower ground floor (LGF) has fourteen (14) rooms.

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Table 2.2

Duct Section	Air Qty(m^3/hr)	Cfm%	Duct Area %	Area (m^2)	Duct Size (m)
LGF	18,729	100	100	0.699	0.94
Document Librarian	58	0.3	*	0.035	0.21
Chief Cataloguer	44	0.2	*	0.035	0.21
General office	1,392	7.9	11.5	0.080	0.32
Mail office	89	0.5	2.0	0.014	0.21
Serial librarian	76	0.4	*	0.035	0.21
Senior Ass. Registrar	89	0.5	2.0	0.014	0.21
Accounts room	208	1.1	2.0	0.014	0.21
Deputy Lib. (tech. Services)	327	1.8	3.5	0.025	0.21
Sec. To dep. Librarian	199	1.1	2.0	0.014	0.21
Deputy librarian	100	0.5	2.0	0.014	0.21
Conference room	998	5.3	9.0	0.063	0.28
Microfilm room	348	1.9	3.5	0.025	0.21
Coffee room	1,048	5.6	10.5	0.073	0.31
Main reading Room	13,753	73.4	79.0	0.552	0.84

C. Upper ground floor has four (4) rooms

Table 2.3

Duct Section	Air Qty(m^3/hr)	Cfm%	Duct Area %	Area (m^2)	Duct Size (m)
UGF	15,859	100	100	0.604	0.88
Catalogue & Orders section	1,100	7	11.5	0.070	0.30
Entrance/ Reception area	1,347	9	14.5	0.088	0.34
Computer Appl. Room	803	5	9.0	0.054	0.26
Reading section	12,609	79	84.0	0.507	0.80

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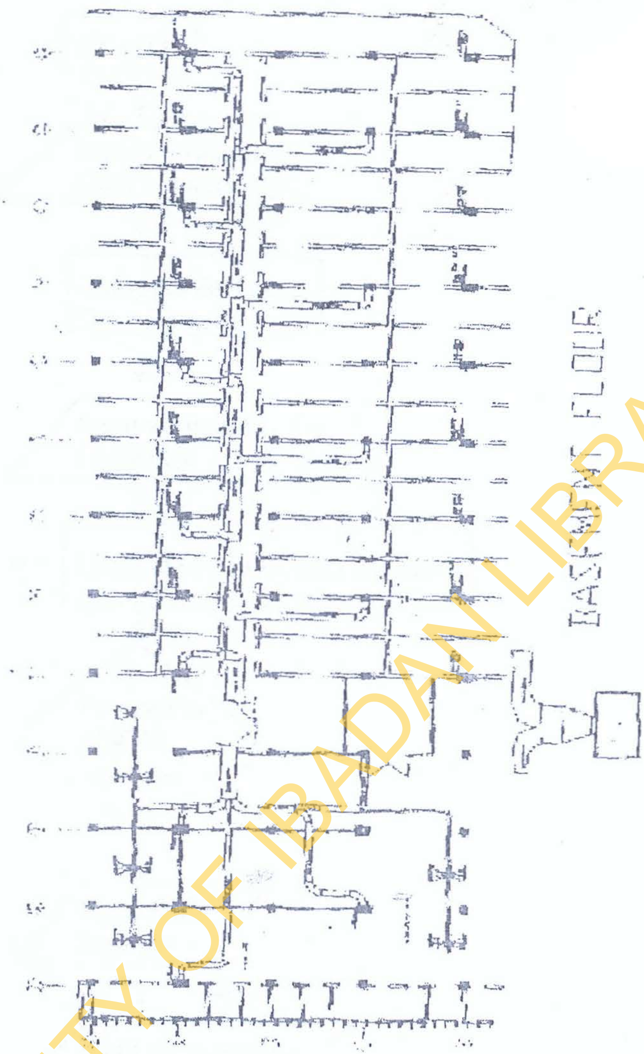

Fig. 1: FLOOR PLAN OF THE BASEMENT FLOOR SHOWING THE DUCT LAYOUT
Fig. 2 FLOW CHART: Ducting Analysis

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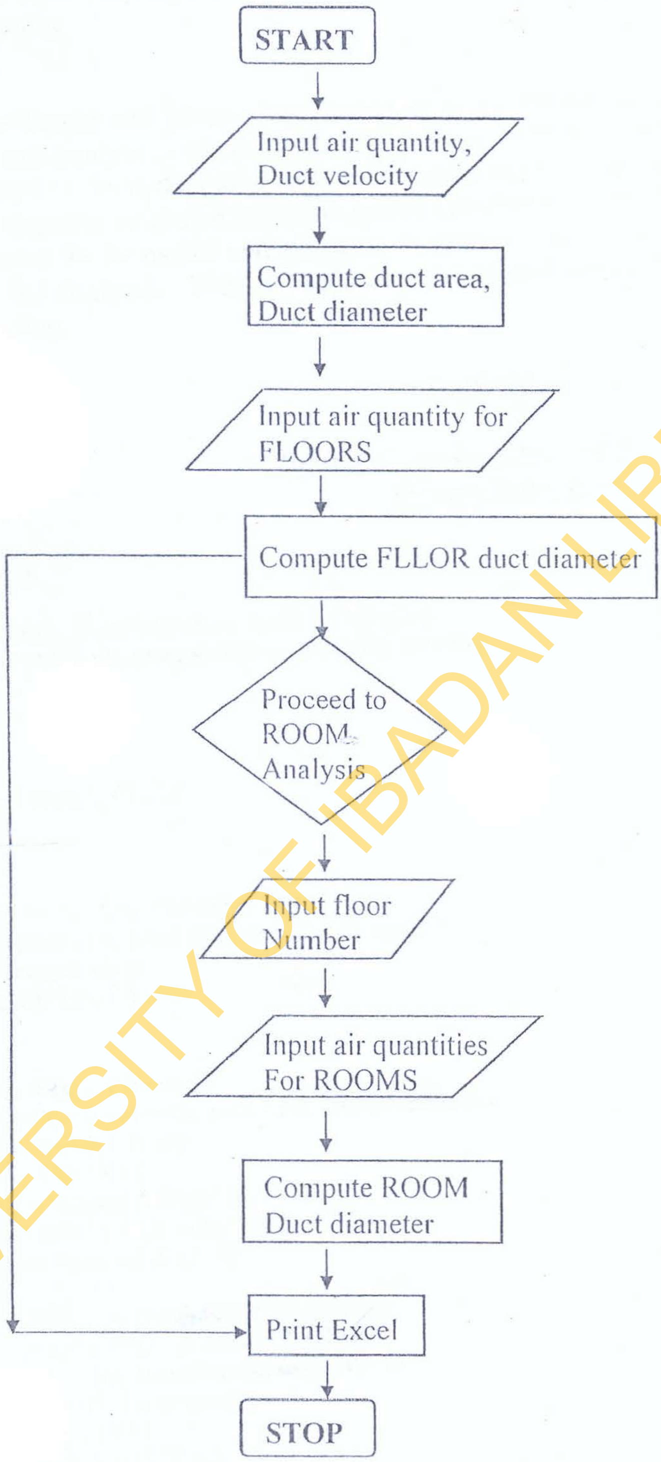

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Discussion

Tables 1.1, 2.1, 2.2 and 2.3 show the results of the hand-calculated analysis for the three floors from the mains and the room analysis for the Basement, Lower ground floor and Upper ground floor respectively. These, when compared with the results of the computer print-out of results from the software package analysis showed that the same values were got, i.e. both methods were accurate and realistic. Obviously, the hand-calculated analysis is more rigorous and time consuming when compared with the computer simulation, which was processed in seconds. Duct area % less than 2%, represented as

* in the hand-calculations of table 2.2, automatically gave the least duct diameter of 0.21m in the software. The floor plan layout of the Basement floor is shown in fig. 1, while fig. 2 shows the flowchart for the programme.

Conclusion

The efficient and proper functioning of an air-conditioning system depends to an extent on the duct design and analysis. Most often, sound level, such as in a library, has to be the limiting factor. Noise generated in ducts depend greatly on the duct velocity used in a system. Thus, the effectiveness of the software depends on proper selection and/or calculations of the basic design parameters. The software itself has proven to be useful and effective in terms of accuracy, time factor and tedious task of hand-calculations for analysis. Thus it becomes a ready tool for professionals and engineering students of higher institution.

Appendix 1

Source Code For Ducting Analysis
(Visual Basic 6.0)

```
option Explicit

Private Sub Form_KeyPress(Key Ascii As Integer)
'this function starts the programme on pressing 'any key
Unload Me
Form 1.Show
End Sub

Private Sub Frame1_Click()
'Unload Me
End Sub

Private Sub Text1_LostFocus()
' DAQ represents the total dehumidified air quantity
On Error Resume Next
DAQ = CDb1(Text1.Text)
End Sub

Private Sub Text2_Change()
'vel represents the velocity, area 1 the area of main duct
VEL = CDb1(Test2.Text)
AREA1 = DAQ / VEL
Text3.Text = Round(AREA1,3)
DIA1 = (4* AREA 1 (3,142)^ 0.5
Text4.Text = Round(DIA1, 3)
End Sub
' DAQ1,DAQ2,...represents the air quantity
'required on each floor, and DIAF1,DIAF2,...
'the diameter of the branch ducts to the floors
private Sub Text5_LostFocus()
On Error Go To FEM
DAQ1 = CDb1(Text5.Text)
a = CFM(DAQ1)
CFM1 = CFMF
B = DUCT(CFM1)
AREAF1 = AREAF
AREAF = 0
DIAF1 = Sqr(4 * AREAF1) / 3.142)
If(DIAF1 < 0.21) Then
Text14.Text = 0.21
AREAF2 = 0
DIAF2 = 0
End Sub
Private Sub Text17_LostFocus()
On Error Go To FEM
DAQ3 = CDb1(Text7.Text)
a = CFM(DAQ3)
CFM3 = CFMF
B = DUCT(CFM3)
AREAF3 = AREAF
AREAF = 0
DIAF3 = Sqr((4 * AREAF3) / 3.142)
If (DIAF3 < 0.21) Then
Text17.Text = 0.21
Else
Text17.Text = Round(DIAF3, 3)
End If
Exit Sub
FEM:
AREAF3 = 0
DIAF3 = 0
End Sub
Private Sub Tex8_LostFocus()
On Error Go To FEM
a = CFM(DAQ4)
CFM4 = CFMF
B = DUCT(CFM4)
AREAF4 = AREAF
AREAF = 0
DIAF4 = Sqr((4 * AREAF4) / 3.142)
If (DIAF4 < 0.21) Then
Text 18.Text = 0.21
Else
Text18.Text = Round(DIAF4, 3)
End If
Exit Sub
FEM:
AREAF4 = 0
DIAF4 = 0
End Sub
```

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```
Else
Text.14.Text = Round(DIAF1, 3)
End If
Exit Sub
FEM:
AREAF1 = 0
End Sub
Private Sub Text6_LostFocus()
On Error Go To FEM
DAQ2 = CDb1(Text6.Text)
a = CFM(DAQ2)
CFM2 = CFMF
B = DUCT(CFM2)
AREAF2 = AREAF
AREAF = 0
DIAF2 = Sqr((4 * AREAF2) / 3.142)
If (DIAF2 < 0.21) Then
Text16.Text = 0.21
Else
Text16.Text = Round(DIAF2, 3)
End If
Exit Sub
FEM:
B = DUCT(CFM6)
AREAF6 = AREAF
AREAF = 0
DIAF6 = Sqr((4 * AREAF6) / 3.142)
If (DIAF6 < 0.21) Then
Text20.Text = 0.21
Else
Text20.Text = Round(DIAF6, 3)
End If
Exit Sub
FEM:
AREAF6 = 0
DIAF6 = 0
End Sub
Private Sub Text11_LostFocus()
On Error Go To FEM
DIAQ7 = CDb1(Text11.Text)
a = CFM(DAQ7)
CFM7 = CFMF
B = DUCT(CFM7)
AREAF7 = AREAF
AREAF = 0
DIAF7 = Sqr((4 * AREAF7) / 3.142)
If (DIAF7 < 0.21) Then
Text21.Text = 0.21
Else
Text21.Text = Round(DIAF7, 3)
End If
Exit Sub
FEM:
AREAF7 = 0
DIAF7 = 0
End Sub
Private Sub Text12_LostFocus()
On Error Go To FEM
```

```
Private Sub Text9_LostFocus()
On Error Go To FEM
DAQ5 = CDb1(Text9.Text)
a = CFM(DAQ5)
CFM5 = CFMF
B = DUCT(CFM5)
AREAF5 = AFEA
AREAF = 0
DIAF5 = Sqr((4 * AREAF5) / 3.142)
If (DIAF5 < 0.21) Then
Text19.Text = 0.21
Text19.Text = Round (DIAF5, 3)
End If
Exit Sub
FEM:
AREAF5 = 0
DIAF5 = 0
End Sub
Private Sub Text10_LostFocus()
On Error Go To FEM
DAQ6 = CDb1(Text10.Text)
a = CFM(DAQ6)
CFM6 = CFMF
DIAF9 = 0
End Sub
```

```
Private Sub Command1_Click()
this function takes the programme to the next form for room analysis
FRMFLOOR.Show
End Sub
```

```
Private Sub Command3_Click()
'this function prints the results as Microsoft Excel output
Dim correxcel As Object
Dim corrwks As Object
Set correxcel = CreateObject("excel.application")
correxcel.workbooks.Add
Set corrwks = correxcel.activesheet
corrwks.cells(1, 1). Value = "Total air qty(m^3/hr)"
corrwks.cells(1, 2). Value = "Duct velocity(m/hr)"
corrwks.cells(1, 3). Value = "Duct area(m^2)"
corrwks.cells(1, 4). Value = "Dia of main duct(m)"
corrwks.cells(2, 1). Value = DAQ
corrwks.cells(2, 2). Value = VEL
corrwks.cells(2, 3). Value = AREA1
corrwks.cells(2, 4). Value = DIA1
corrwks.cells(5, 1). Value = "FLOOR NOS"
corrwks.cells(5, 2). Value = "AIR QTY(m^3/hr)"
corrwks.cells(5, 3). Value = "DUCT DIA(m)"
corrwks.cells(6, 1). Value = "1"
corrwks.cells(6, 2). Value = DAQ1
corrwks.cells(6, 3). Value = DIAF1
corrwks.cells(7, 1). Value = "2"
corrwks.cells(7, 2). Value = DAQ2
corrwks.cells(7, 3). Value = DIAF2
```

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```
DAQ8 = CDb1(Text12.Text)
a = CFM(DAQ8)
CFM8 = CFMF
B = DUCT(CFM8)
AREAF8 = AREAF
AREAF = 0
DIAF8 = Sqr((4 * AREAF8) / 3.142)
If (DIAF8 < 0.21) Then
Text22.Text = 0.21
Else
Text22.Text = Round(DIAF8, 3)
End If
Exit Sub
FEM:
AREAF8 = 0
DIAF8 = 0
End Sub
Private Sub Text13_LostFocus()
On Error Go To FEM
DAQ9 = CDb1(Text13.Text)
a = CFM(DAQ9)
CFM9 = CFMF
B = DUCT(CFM9)
AREAF9 = AREAF
AREAF = 0
DIAF9 = Sqr((4 * AREAF9) / 3.142)
If (DIAF9 < 0.21) Then
Text23.Text = 0.21
Else
Text23.Text = Round(DIAF9,3)
End If
Exit Sub
FEM:
AREAF9 = 0
ElseIf (NOS = 2) Then
Text2.Text = DAQ2
Text3.Text = DIAF2
a = change()
ElseIf (NOS = 3) Then
Text2.Text = DAQ2
a = change()
ElseIf (NOS = 4) Then
Text2.Text = DAQ4
Text3.Text = DIAF4
a = change()
ElseIf (NOS = 5) Then
Text2.Text = DAQ5
Text3.Text = DIAF5
a = change()
ElseIf (NOS = 6) Then
Text2.Text = DAQ6
Text3.Text = DIAF6
a = change()
ElseIf (NOS = 7) Then
Text2.Text = DAQ7
Text3.Text = DIAF7
```

```
corrwks.cells(8, 1). Value = "3"
corrwks.cells(8, 2). Value = DAQ3
corrwks.cells(8, 3). Value = DIAF3
corrwks.cells(9, 1). Value = "4"
corrwks.cells(9, 2). Value = DAQ4
corrwks.cells(9, 3). Value = DIAF4
corrwks.cells(10, 1). Value = "5"
corrwks.cells(10, 2). Value = DAQ5
corrwks.cells(10, 3). Value = DIAF5
corrwks.cells(11, 1). Value = "6"
corrwks.cells(11, 2). Value = DAQ6
corrwks.cells(11, 3). Value = DIAF6
corrwks.cells(12, 1). Value = "7"
corrwks.cells(12, 2). Value = DAQ7
corrwks.cells(12, 3). Value = DIAF7
corrwks.cells(13, 1). Value = "8"
corrwks.cells(13, 2). Value = DAQ8
corrwks.cells(13, 3). Value = DIAF8
corrwks.cells(14, 1). Value = "9"
corrwks.cells(14, 2). Value = DAQ9
corrwks.cells(14, 3). Value = DIAF9
correxcel.save
correxcel.quit
End Sub

Private Sub Text1_Lost Focus()
'this function takes the floor number that the user
'inputs, and automatically calls the air quantity
'and diameter of the duct for that floor number
NOS = CDb1(Text1.Text)
If (NOS = 1) Then
Text2.Text = DAQ1
Text3.Text = DIAF1
a = change()
FEM:
AREAR11 = 0
DIAR11 = 0
End Sub
FEM:
AREAR11 = 0
End Sub
a = CFN(DAQR12)
CFMR12 = CFMF
B = DUCT(CFMR12)
AREAR12 = AREAF
AREAR = 0
DIAR12 = Sqr((4 * AREAR12) / 3.142)
DIAR12 = confirm(DIAR12)
AREAR12 = AREAF
Exit Sub
FEM:
AREAR12 = 0
AREAR12 = AREAF
End Sub
Private Sub Text 18_LostFocus()
On Error Go To FEM
```

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```
a = change()
ElseIf (NOS = 8) Then
Text2.Text = DAQ8
Text3.Text = DIAF8
a = change()
ElseIf (NOS = 9) Then
Text2.Text = DAQ9
Text3.Text = DIAF9
a = change()
End If
End Sub
'this function does the room analysis for the
'floors, using the air quantity for each room
'to determine the duct sizes
Private Sub Text 14_LostFocus()
On Error Go To FEM
DAQR10 = CDb1(Text14.Text)
a = CFM(DAQR10)
CFMR10 = CFMF
B = DUCT(CFMR10)
AREA10 = AREAF
AREAF = 0
DIAR10 = Sqr((4 * AREAR10) / 3.142)
DIAR10 = confirm(DIAR10)
Text35.Text = Round(DIAR10, 3)
Exit Sub
FEM:
AREAR1 = 0
DIAR1 = 0
End Sub
Private Sub Text16_LostFocus()
On Error Go To FEM
DAQR11 = CDb1(Text16.Text)
a = CFM(DAQR11)
CFMR11 = CFMF
B = DUCT(CFMR11)
AREAR11 = AREAF
AREAF = 0
DIAR11 = Sqr((4 * AREAR11) / 3.142)
DIAR11 = confirm(DIAR11)
Text36.Text = Round(DIAR11, 3)
Exit Sub
FEM:
AREAR15 = 0
DIAR15 = 0
End Sub
Private Sub Text21_LostFocus()
On Error Go To FEM
DAQR16 = CDb1(Text21.Text)
a = CFM(DAQR16)
CFMR16 = CFMF
B = DUCT(CFMR16)
AREAR16 = AREAF
AREAF = 0
DIAR16 = Sqr((4 * AREAR16) / 3.142)
DIAR16 = confirm(DIAR16)
AREAR12 = AREAF
a = CFM(DAQR13)
CFMR13 = CFMF
B = DUCT(CFMR13)
AREAR13 = AREAF
AREAF = 0
DIAR13 = Sqr((4 * AREAR12) / 3.142)
DIAR13 = confirm(DIAR13)
Text38.Text = Round(DIAR13, 3)
Exit Sub
FEM:
AREAR13 = 0
DIAR13 = 0
End Sub
Private Sub Text19_LostFocus()
On Error Go To FEM
DAQR14 = CDb1(Text19.Text)
a = CFM(DAQR14)
CFMR14 = CFMF
B = DUCT(CFMR14)
AREAR14 = AREAF
AREAF = 0
DIAR14 = Sqr((4 * AREAR14) / 3.142)
DIAR14 = confirm(DIAR14)
Text39.Text = Round(DIAR14, 3)
Exit Sub
FEM:
AREAR14 = 0
DIAR14 = 0
End Sub
Private Sub Text20_LostFocus()
On Error Go To FEM
DAQR15 = CDb1(Text20.Text)
a = CFM(DAQR15)
CFMR15 = CFMF
B = DUCT(CFMR15)
AREAR15 = AREAF
AREAF = 0
DIAR15 = Sqr((4 * AREAR15) / 3.142)
DIAR15 = confirm(DIAR15)
Text40.Text = Round(DIAR15, 3)
Exit Sub
FEM:
AREAR19 = 0
AREAR19 = 0
End Sub
Private Sub Text25_LostFocus()
On Error Go To FEM
DAQR20 = CDb1(Text25.Text)
a = CFM(DAQR20)
CFMR20 = CFMF
B = DUCT(CFMR20)
AREAR20 = AREAF
AREAF = 0
DIAR16 = Sqr((4 * AREAR20) / 3.142)
DIAR20 = confirm(DIAR20)
```

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```
Text41.Text = Round(DIAR16, 3)
Exit Sub
FEM:
AREAR16 = 0
DIAR16 = 0
End Sub
Private Sub Text22_LostFocus()
On Error Go To FEM
DAQR17 = CDb1(Text22.Text)
a = CFM(DAQR17)
CFMR17 = CFMF
B = DUCT(CFMR17)
AREAR17 = AREAF
AREAF = 0
DIAR17= Sqr((4 * AREAR17) / 3.142)
DIAR17 = confirm(DIAR17)
Text41.Text = Round(DIAR17, 3)
Exit Sub
FEM:
AREAR17 = 0
DIAR17 = 0
End Sub
Private Sub Text23_LostFocus()
On Error Go To FEM
DAQR18 = CDb1(Text23.Text)
a = CFM(DAQR18)
CFMR17 = CFMF
B = DUCT(CFMR18)
AREAR18 = AREAF
AREAF = 0
DIAR18 = Sqr((4 * AREAR18) / 3.142)
DIAR18 = confirm(DIAR18)
Text43.Text = Round(DIAR18, 3)
Exit Sub
FEM:
AREAR18 = 0
DIAR18 = 0
End Sub
Private Sub Text24_LostFocus()
On Error Go To FEM
DAQR19 = CDb1(Text24.Text)
a = CFM(DAQR19)
CFMR19 = CFMF
B = DUCT(CFMR19)
AREAR19 = AREAF
AREAF = 0
DIAR19 = Sqr((4 * AREAR19) / 3.142)
DIAR19 = confirm(DIAR19)
Text44.Text = Round(DIAR19, 3)
Exit Sub
FEM:


End Sub
Private Sub Text8_LostFocus()
On Error Go To FEM
```

```
Text45.Text = Round(DIAR20, 3)
Exit Sub
FEM:
AREAR20 = 0
DIAR20 = 0
End Sub
Private Sub Text22_LostFocus()
On Error Go To FEM
DAQR1 = CDb1(Text5.Text)
a = CFM(DAQR1)
CFMR1 = CFMF
B = DUCT(CFMR1)
AREAR1 = AREAF
AREAF = 0
DIAR1= Sqr((4 * AREAR16) / 3.142)
DIAR1 = confirm(DIAR1)
Text26.Text = Round(DIAR1, 3)
Exit Sub
FEM:
AREAR1 = 0
DIAR1 = 0
End Sub
Private Sub Text6_LostFocus()
On Error Go To FEM
DAQR2 = CDb1(Text6.Text)
a = CFM(DAQR2)
CFMR1 = CFMF
B = DUCT(CFMR2)
AREAR2 = AREAF
AREAF = 0
DIAR2 = Sqr((4 * AREAR2) / 3.142)
DIAR2 = confirm(DIAR2)
Text27.Text = Round(DIAR2, 3)
Exit Sub
FEM:
AREAR2 = 0
DIAR2 = 0
End Sub
Private Sub Text7_LostFocus()
On Error Go To FEM
DAQR3 = CDb1(Text7.Text)
a = CFM(DAQR3)
CFMR3 = CFMF
B = DUCT(CFMR3)
AREAR3 = AREAF
AREAF = 0
DIAR3= Sqr((4 * AREAR3) / 3.142)
DIAR3 = confirm(DIAR3)
Text28.Text = Round(DIAR3, 3)
Exit Sub
FEM:
AREA31 = 0
DIAR3 = 0
DAQR8 = CDb1(Text12.Text)
a = CFM(DAQR8)
CFMR8 = CFMF
```

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```
DAQR4 = CDb1(Text8.Text)
a = CFM(DAQR4)
CFMR4 = CFMF
B = DUCT(CFMR4)
AREAR4 = AREAF
AREAF = 0
DIAR4 = Sqr((4 * AREAR4) / 3.142)
DIAR4 = confirm(DIAR4)
Text29.Text = Round(DIAR4, 3)
Exit Sub
FEM:
AREAR4 = 0
DIAR4 = 0
End Sub
Private Sub Text19_LostFocus()
On Error Go To FEM
DAQR5 = CDb1(Text9.Text)
a = CFM(DAQR5)
CFMR5 = CFMF
B = DUCT(CFMR5)
AREAR5 = AREAF
AREAF = 0
DIAR5 = Sqr((4 * AREAR5) /3.142)
DIAR5 = confirm(DIAR5)
Text30.Text = Round(DIAR5; 3)
Exit Sub
FEM:
AREAR5 = 0
DIAR5 = 0
DIAR5 = 0
End Sub
Private Sub Text10_LostFocus()
On Error Go To FEM
DAQR6 = CDb1(Text10.Text)
a = CFM(DAQR6)
CFMR6 = CFMF
B = DUCT(CFMR6)
AREAR6 = AREAF
AREARF = 0
DIAR6 = Sqr((4 * AREAR6) /3.142)
DIAR6 = confirm(DIAR6)
Text31.Text = Round(DIAR6, 3)
Exit Sub
FEM:
AREAR6 = 0
DIAR6 = 0
End Sub
Private Sub Text11_LostFocus()
On Error Go To FEM
DAQR7 = CDb1(Text11.Text)
a = CFM(DAQR7)
CFMR7 = CFMF
B = DUCT(CFMR7)
AREAR7 = AREAF
AREARF = 0
DIAR7 = Sqr((4 * AREAR7) /3.142)
B = DUCT(CFMR8)
AREAR8 = AREAF
AREAF = 0
DIAR8 = sqr((4 * AREAR8) / 3.142)
DIAR8 = confirm(DIAR8)
Text33.Text = Round(DIAR8, 3)
Exit Sub
FEM:
AREAR8 = 0
DIAR8 = 0
End Sub
Private Sub Text13_LostFocus()
On Error Go To FEM
DAQR9 = CDb1(Text13.Text)
a = CFM(DAQR9)
CFMR9 = CFMF
B = DUCT(CFMR9)
AREAR9 = AREAF
AREAF = 0
DIAR9 = Sqr((4 * AREAR9) / 3.142)
DIAR9 = confirm(DIAR9)
Text34.Text = Round(DIAR9, 3)
Exit Sub
FEM:
AREAR9 = 0
DIAR9 = 0
End Sub

Private Sub Command1_Click()
'this function prints the results as Microsoft Excel output
Dim correxcel As Object
Dim corrwks As Object
Set correxcel = CreateObject("excel.application")
correxcel.workbooks.Add
Set corrwks = correxcel.activesheet
corrwks.cells(1, 1). Value = "Floor air qty(m^3/hr)"
corrwks.cells(1, 2). Value = "Total nos"
corrwks.cells(1, 3). Value = "Duct diameter(m)"
corrwks.cells(2, 1). Value = Text2.Text
corrwks.cells(2, 2). Value = "Text1.Text
corrwks.cells(2, 3). Value = "Text3.Text
corrwks.cells(5, 1). Value = "ROOM NOS"
corrwks.cells(5, 2). Value = "AIR QTY(m^3/hr)"
corrwks.cells(5, 3). Value = "DUCT DIA(m)"
corrwks.cells(6, 1). Value = "1"
corrwks.cells(6, 2). Value = Text5.Text
corrwks.cells(6, 3). Value = Text26.Text
corrwks.cells(7, 1). Value = "2"
corrwks.cells(7, 2). Value = Text6.Text
corrwks.cells(7, 3). Value = Text27.Text
corrwks.cells(8, 1). Value = "3"
corrwks.cells(8, 2). Value = Text7.Text
corrwks.cells(8, 3). Value = Text28.Text
corrwks.cells(9, 1). Value = "4"
corrwks.cells(9, 2). Value = Text8.Text
```

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```
DIAR7 = confirm(DIAR7)
Text32.Text = Round(DIAR7, 3)
Exit Sub
FEM:
AREAR7 = 0
DIAR7 = 0
End Sub
Private Sub Text12_LostFocus()
On Error Go To FEM
corrwks.cells(12 , 3). Value = Text32.Text
corrwks.cells(13, 1). Value = "8"
corrwks.cells(13, 2). Value = Text12.Text
corrwks.cells(13, 3). Value = Text33.Text
corrwks.cells(14, 1). Value = "9"
corrwks.cells(14, 2). Value = Text13.Text
corrwks.cells(14, 3). Value = Text34.Text
corrwks.cells(15, 1). Value = "10"
corrwks.cells(15, 2). Value = Text14.Text
corrwks.cells(15, 3). Value = Text35.Text
corrwks.cells(16, 1). Value = "11"
corrwks.cells(16, 2). Value = Text16.Text
corrwks.cells(16, 3). Value = Text36.Text
corrwks.cells(17, 1). Value = "12"
corrwks.cells(17, 2). Value = Text17.Text
corrwks.cells(17, 3). Value = Text37.Text
corrwks.cells(18, 1). Value = "13"
corrwks.cells(18, 2). Value = Text18.Text
corrwks.cells(18, 3). Value = Text38.Text
corrwks.cells(19, 1). Value = "14"
corrwks.cells(19, 2). Value = Text19.Text
corrwks.cells(19, 3). Value = Text39.Text
corrwks.cells(20, 1). Value = "15"
corrwks.cells(20, 2). Value = Text20.Text
corrwks.cells(20, 3). Value = Text40.Text
corrwks.cells(21, 1). Value = "16"
corrwks.cells(21, 2). Value = Text21.Text
corrwks.cells(21, 3). Value = Text41.Text
corrwks.cells(22, 1). Value = "17"
corrwks.cells(22, 2). Value = Text22.Text
corrwks.cells(22, 3). Value = Text42.Text
corrwks.cells(23, 1). Value = "18"
corrwks.cells(23, 2). Value = Text23.Text
corrwks.cells(23, 3). Value = Text43.Text
corrwks.cells(24, 1). Value = "19"
corrwks.cells(24, 2). Value = Text24.Text
corrwks.cells(24, 3). Value = Text44.Text
corrwks.cells(25, 1). Value = "20"
corrwks.cells(25, 2). Value = Text25.Text
corrwks.cells(25, 3). Value = Text45.Text
correxcel.save
correxcel.quit
End Sub
corrwks.cells(9, 3). Value = "Text29.Text
corrwks.cells(10, 1). Value = "5"
corrwks.cells(10, 2). Value = Text9.Text
corrwks.cells(10, 3). Value = Text30.Text
corrwks.cells(11, 1). Value = Text6.Text
corrwks.cells(11, 2). Value = Text10.Text
corrwks.cells(11, 3). Value = Text31.Text
corrwks.cells(12, 1). Value = Text7.Text
corrwks.cells(12, 2). Value = Text11.Text
AREAF = DA * AREA1
ElseIf (S = 7) Then
DA = (11.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 8) Then
DA = (13 / 100)
AREAF = DA * AREA1
ElseIf (S = 9) Then
DA = (16.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 10) Then
DA = (16.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 11) Then
DA = (17.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 12) Then
DA = (18.5 / 100)
AREAR = DA * AREA1
ElseIf (S = 13) Then
DA = (19.5 / 100)
AREAF = DA * AREA1
Else (S = 14) Then
DA (20.5 / 100)
AREAR = DA * AREA1
ElseIf (S = 15) Then
DA = (21.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 16) Then
DA = (23 / 100)
AREAF = DA * AREA1
ElseIf (S = 17) Then
DA = (24 / 100)
AREAF = DA * AREA1
ElseIf (S = 18) Then
DA = (25 / 100)
AREAF = DA * AREA1
ElseIf (S = 19) Then
DA = (26 / 100)
AREAF = DA * AREA1
ElseIf(S = 20) Then
DA = (27 / 100)
AREAF = DA * AREA1
ElseIf(S = 21) Then DA = (28 / 100)
```

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```
Public DAQ, VEL, AREA1, DIA1, CFMF, AREAF, DIAF1,
DIAF2, DIAF3, DIAF4, DIAF5, DIAF6, DIAF7, DIAF8,
DIAF9, DAQ1, DAQ2, DAQ3, DAQ4, DAQ5, DAQ6,
DAQ7, DAQ8, DAQ9, As Double
Public Function CFM(W)
CFMF = Round((W * 100 / DAQ), 0)
End Function
Public Function DUCT(S)
.If (S = 1) Then
DA = (2 / 100)
AREAF = DA * AREA1
ElseIf (S = 2) Then
DA = (3.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 3) Then
DA = (5.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 4) Then
DA = (7 / 100)
AREAF = DA * AREA1
ElseIf (S = 5) Then
DA = (9 / 100)
AREAF = DA * AREA1
ElseIf (S = 29) Then
DA = (36.5 / 100)
ElseIf (S = 2) Then
DA = (3.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 30) Then
DA = (37.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 31) Then
DA = (39 / 100)
AREAF = DA * AREA1
ElseIf (S = 32) Then
DA = (40 / 100)
AREAF = DA * AREA1
ElseIf (S = 32) Then
DA = (40 / 100)
AREAF = DA * AREA1
ElseIf (S = 33) Then
DA = (41 / 100)
AREAF = DA * AREA1
ElseIf (S = 34) Then
DA = (42 / 100)
AREAF = DA * AREA1
ElseIf (S = 35) Then
DA = (43 / 100)
AREAF = DA * AREA1
ElseIf (S = 36) Then
DA = (44 / 100)
AREAF = DA * AREA1
ElseIf (S = 37) Then
DA = (45 / 100)
AREAF = DA * AREA1
ElseIf (S = 38) Then
AREAF = DA * AREA1
ElseIf(S = 22) Then
DA = (29.5 / 100)
AREAF = DA * AREA1
ElseIf(S = 23) Then
DA = (30.5 / 100)
AREAF = DA * AREA1
ElseIf(S= 24) Then
DA = (31.5 / 100)
AREAF = DA * AREA1
ElseIf(S= 25) Then
DA = (32.5 / 100)
AREAF = DA * AREA1
ElseIf(S= 26) Then
DA = (33.5 / 100)
AREAF = DA * AREA1
ElseIf(S= 25) Then
DA = (34.5 / 100)
AREAF = DA * AREA1
ElseIf(S= 28) Then
DA = (35.5 / 100)
AREAF = DA * AREA1

DA = (59 / 100)
AREAF = DA * AREA1
ElseIf(S= 52) Then
DA = (60 / 100)
AREAF = DA * AREA1
ElseIf(S= 53) Then
DA = (61 / 100)
AREAF = DA * AREA1
ElseIf(S= 54) Then
DA = (32.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 62) Then
DA = (32.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 55) Then
DA = (63 / 100)
AREAF = DA * AREA1
ElseIf (S=56) Then
DA = (64 / 100)
AREAF = DA * AREA1
ElseIf (S= 57) Then
DA = (65 / 100)
AREAF = DA * AREA1
ElseIf (S= 58) Then
DA = (65.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 59) Then
DA = (66.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 60) Then
DA = (67.5 / 100)
```

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```
DA = (46 / 100)
AREAF = DA * AREA1
ElseIf (S = 39) Then
DA = (47 / 100)
AREAF = DA * AREA1
ElseIf (S = 40) Then
DA = (48 / 100)
AREAF = DA * AREA1
ElseIf (S = 41) Then
DA = (49 / 100)
AREAF = DA * AREA1
ElseIf (S = 42) Then
DA = (50 / 100)
AREAF = DA * AREA1
ElseIf (S = 43) Then
DA = (51 / 100)
AREAF = DA * AREA1
ElseIf (S = 44) Then
DA = (52 / 100)
AREAF = DA * AREA1
ElseIf (S = 45) Then
DA = (53 / 100)
AREAF = DA * AREA1
ElseIf (S = 46) Then
DA = (54 / 100)
AREAF = DA * AREA1
ElseIf (S = 47) Then
DA = (55 / 100)
AREAF = DA * AREA1
ElseIf (S = 48) Then
DA = (56 / 100)
AREAF = DA * AREA1
ElseIf (S = 49) Then
DA = (57 / 100)
AREAF = DA * AREA1
ElseIf (S = 50) Then
DA = (58 / 100)
AREAF = DA * AREA1
ElseIf (S = 51) Then
DA = (79 / 100)
AREAF = DA * AREA1
ElseIf (S= 74) Then
DA = (80 / 100)
AREAF = DA * AREA1
ElseIf (S= 75) Then
DA = (80.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 76) Then
DA = (81 / 100)
AREAF = DA * AREA1
ElseIf (S= 77) Then
DA = (82 / 100)
AREAF = DA * AREA1
ElseIf (S= 78) Then
DA = (83 / 100)
AREAF = DA * AREA1
```

```
AREAF = DA * AREA1
ElseIf (S= 61) Then
DA = (68 / 100)
AREAF = DA * AREA1
ElseIf (S= 62) Then
DA = (69 / 100)
AREAF = DA * AREA1
ElseIf (S= 63) Then
DA = (70 / 100)
AREAF = DA * AREA1
ElseIf (S= 64) Then
DA = (71 / 100)
AREAF = DA * AREA1
ElseIf (S= 65) Then
DA = (71.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 66) Then
DA = (72.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 67) Then
DA = (73.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 68) Then
DA = (74.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 69) Then
DA = (75.5 / 100)
AREAF = DA * AREA1
ElseIf (S = 70) Then
DA = (76.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 71) Then
DA = (77 / 100)
AREAF = DA * AREA1
ElseIf (S= 72) Then
DA = (78 / 100)
AREAF = DA * AREA1
ElseIf (S= 73) Then

ElseIf (S= 96) Then
DA = (96.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 97) Then
DA = (97.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 98) Then
DA = (98 / 100)
AREAF = DA * AREA1
ElseIf (S= 99) Then
DA = (99 / 100)
AREAF = DA * AREA1
ElseIf (S= 100) Then
DA = (100 / 100)
AREAF = DA * AREA1
End If
End Function
```

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```
ElseIf (S= 79) Then
DA = (84 / 100)
AREAF = DA * AREA1
ElseIf (S= 80) Then
DA = (84.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 81) Then
DA = (85 / 100)
AREAF = DA * AREA1
ElseIf (S= 82) Then
DA = (86 / 100)
AREAF = DA * AREA1
ElseIf (S= 83) Then
DA = (86.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 84) Then
DA = (87 / 100)
AREAF = DA * AREA1
ElseIf (S= 85) Then
DA = (87 / 100)
AREAF = DA * AREA1
ElseIf (S= 86) Then
DA = (88 / 100)
AREAF = DA * AREA1
ElseIf (S= 87) Then
DA = (89.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 88) Then
DA = (90 / 100)
AREAF = DA * AREA1
ElseIf (S= 89) Then
DA = (91 / 100)
AREAF = DA * AREA1
ElseIf (S= 90) Then
DA = (92 / 100)
AREAF = DA * AREA1
ElseIf (S= 91) Then
DA = (93 / 100)
AREAF = DA * AREA1
ElseIf (S= 92) Then
DA = (94 / 100)
AREAF = DA * AREA1
ElseIf (S= 93) Then
DA = (94.5 / 100)
AREAF = DA * AREA1
ElseIf (S= 94) Then
DA = (95 / 100)
AREAF = DA * AREA1
ElseIf (S= 95) Then
DA = (96 / 100)
AREAF = DA * AREA1
```

```
Public Function confirm(a)
If (a < 0.21) Then
confirm = 0.21
Else
confirm = a
End If
End Function
Public Function chabnge()
FRMFLOOR.Text5 = 0
FRMFLOOR.Text6 = 0
FRMFLOOR.Text7 = 0
FRMFLOOR.Text8 = 0
FRMFLOOR.Text9 = 0
FRMFLOOR.Text10 = 0
FRMFLOOR.Text11 = 0
FRMFLOOR.Text12 = 0
FRMFLOOR.Text13 = 0
FRMFLOOR.Text14 = 0
FRMFLOOR.Text16 = 0
FRMFLOOR.Text17 = 0
FRMFLOOR.Text18 = 0
FRMFLOOR.Text19 = 0
FRMFLOOR.Text20 = 0
FRMFLOOR.Text21 = 0
FRMFLOOR.Text22 = 0
FRMFLOOR.Text23 = 0
FRMFLOOR.Text24 = 0
FRMFLOOR.Text25 = 0
FRMFLOOR.Text26 = 0
FRMFLOOR.Text27 = 0
FRMFLOOR.Text28 = 0
FRMFLOOR.Text29 = 0
FRMFLOOR.Text30 = 0
FRMFLOOR.Text31 = 0
FRMFLOOR.Text32 = 0
FRMFLOOR.Text33 = 0
FRMFLOOR.Text34 = 0
FRMFLOOR.Text35 = 0
FRMFLOOR.Text36 = 0
FRMFLOOR.Text37 = 0
FRMFLOOR.Text38 = 0
FRMFLOOR.Text39 = 0
FRMFLOOR.Text40 = 0
FRMFLOOR.Text41 = 0
FRMFLOOR.Text42 = 0
FRMFLOOR.Text43 = 0
FRMFLOOR.Text44 = 0
FRMFLOOR.Text45 = 0
End Function
```

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