



AL-MUSTANSIRIYA UNIVERSITY
College of Engineering
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Design A Computer Program for Calculating Deformation of Beams

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SUPERVISOR CERTIFICATE

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿أَقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ ﴿١﴾ خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ ﴿٢﴾ أَقْرَأْ وَرَبُّكَ

الْأَكْرَمُ ﴿٣﴾ الَّذِي عَلَّمَ بِالْقَلَمِ ﴿٤﴾ عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ ﴿٥﴾﴾

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ونخص بجزيل الشكر والعرفان الى:

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Dedicated To:

إلى صاحب السيرة العطرة، والفكر المستنير؛ فلقد كان له الفضل
الأوّل في بلوغي التعليم العالي
(والدي الحبيب)، أطال الله في عُمره.

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1

CHAPTER ONE

Introduction

INTRODUCTION

1.1 General introduction:

The concept of programming has become widely popular these days, as the large number of programs used in computer hardware made the user not suffer from difficulties facing him, as these programs are varied and not limited to a specialty, but included all specializations and different languages of the world, and they have become accredited means within many professions as they give Accurate results and speedy completion, in addition to that, its ease of use, as it is not limited to the programmer only, but all people of different specialties can use it.

1.2 Beams:

A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. The total effect of to all the forces acting on the beam is to produce shear forces and bending moments within the beam, that in turn induce internal stresses, strains and deflections of the beam. Beams are characterized by their manner of support, profile (shape of cross-section), equilibrium conditions, length, and their material, Beams are traditionally descriptions of building or civil engineering structural elements, but any structures such as automotive automobile frames, aircraft components, machine frames, and other mechanical or structural systems contain beam structures that are designed to carry lateral loads are analyzed in a similar fashion.

1.2.1 History of beams:

Historically beams were squared timbers but are also metal, stone, or combinations of wood and metal such as a flitch beam. Beams primarily carry vertical gravitational forces. They are also used to carry horizontal loads (e.g., loads due to an earthquake or wind or in tension to resist rafter thrust as a tie beam or (usually) compression as a collar beam). The loads carried by a beam are transferred to columns, walls, or girders, which then transfer the force to adjacent structural compression members and eventually to the ground.

In light frame construction, joists may rest on beams.

1.3 Types of beams:

Types of Beams in Constructions:

There are different types of beams which are classified based on the following conditions:

- ❖ Based on Support Conditions
- ❖ Based on Construction Materials
- ❖ Based on Cross-Section Shapes
- ❖ Based on Geometry
- ❖ Based on Equilibrium Condition
- ❖ Based on Method of Construction
- ❖ Others

Based on Support Conditions:

1. Simply Supported Beam:

It is one of the simplest structural elements that both ends rest on supports but is free to rotate. It contains pinned support at one end and a roller support at the other end. Based on the assigned load, it sustains shearing and bending. As shown Fig.(1).

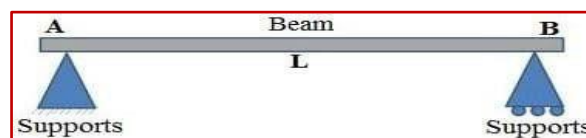


Fig (1) simply supported beam

2. Fixed Ended Beam:

It is supported at both ends and fixed to resist rotation. It is also called a built-in beam the fixed ends produce moments other than the reactions. As shown in Fig. (2).

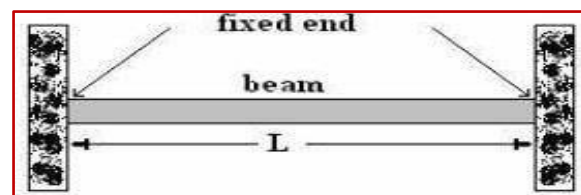


Fig (2) fixed beam

3. Cantilever Beam:

If a beam is fixed at one end and set to be free at the other end, it is termed as

a cantilever beams. The beam distributes the load back to the support where it is forced against a moment and shear stress. Cantilever beams allow the creation of a bay window, as shown in Fig.(3).



Fig (3) cantilever beams

4. Continuous Beam:

A continuous beam has more than two supports distributed along its entire length. As shown in Fig. (4).

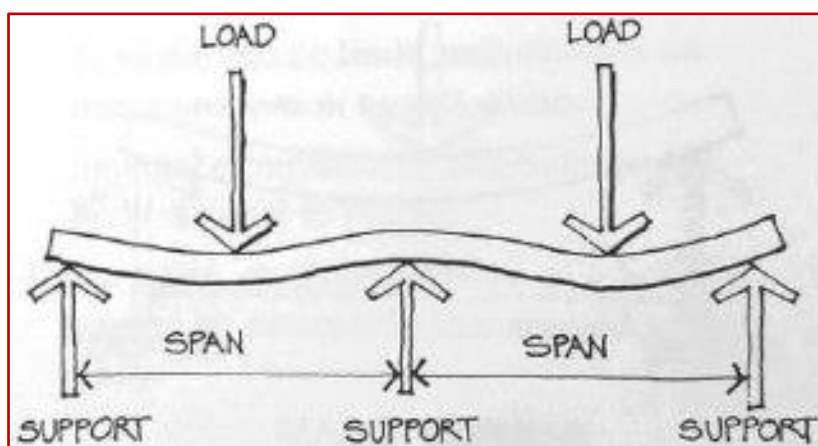


Fig (4) Continuous beam

Based on Construction Materials

5. Reinforced Concrete Beams:

It is constructed from concrete and reinforcement as shown in Fig.(5). Sometimes reinforced concrete beam is concealed in reinforced concrete slabs and it is called hidden beam or concealed beam

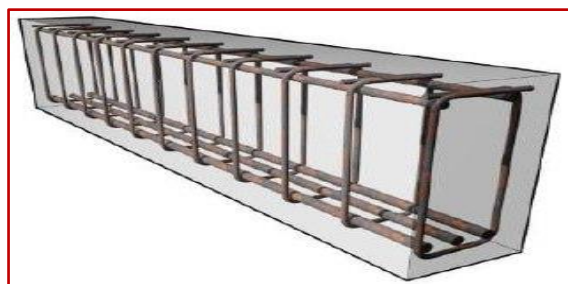


Fig (5) Reinforced concrete beam

6. Steel Beams:

It is constructed from steels and used in several applications.as shown in Fig. (6)



Fig (6) steel beams

7. Timber beams:

The timber beam is constructed from timber and used in the past However, the application of such a beam in the construction industry is significantly declined now. shown in Fig.(7).



Fig (7) timber beams

8. Composite Beams:

Composite beams are constructed from two or more different types of materials such as steel and concrete. Fig. 8 shows Different valid cross-sections for the composite beam.

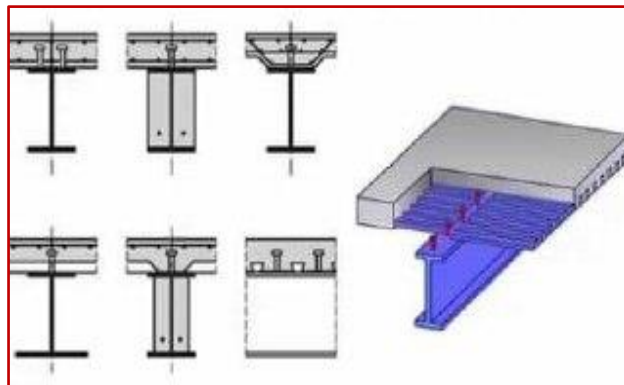


Fig (8) Composite beam

Based on Cross-Section Shapes

Several cross-sectional shapes of beams are available and used in different parts of structures. These beams can be constructed from reinforced concrete, steel, or composite materials

9. Rectangular beam:

This type of beam is widely used in the construction of reinforced concrete buildings and other structures. as shown in Fig. (9).

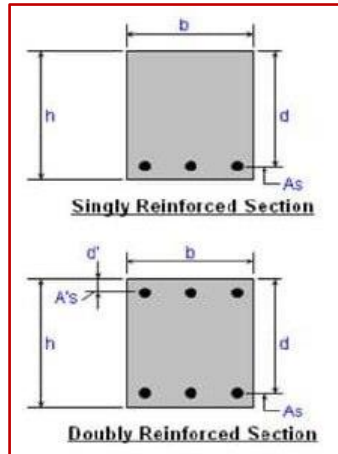


Fig (9) Rectangular Reinforced concrete beam

10. T-section beam:

This type of beam is mostly constructed monolithically with a reinforced concrete slab. Sometimes, Isolated T-beam is built to increase the compression strength of concrete. Added to that, inverted T-beam can also be constructed according to the requirements of loading imposed. As shown in Fig. (10)

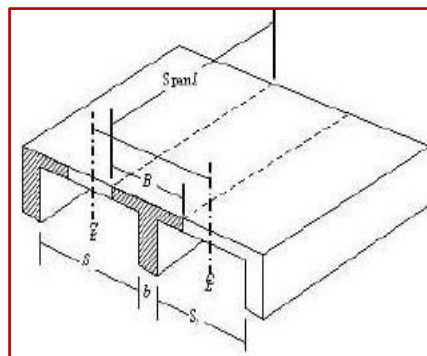


Fig (10) T-beam

11. L-section beam:

This type of beam is constructed monolithically with a reinforced concrete slab at the perimeter of the structure, as illustrated in Fig. (10). There are various steel beam cross sectional shapes. Each cross-sectional shape offers superior advantages in a given

condition compare with other shapes. Square, rectangular, circular, I-shaped, T-shaped, H-shaped, C-shaped, and tubular are examples of beam cross-sectional shapes constructed from steel.as shown in Fig .(11).

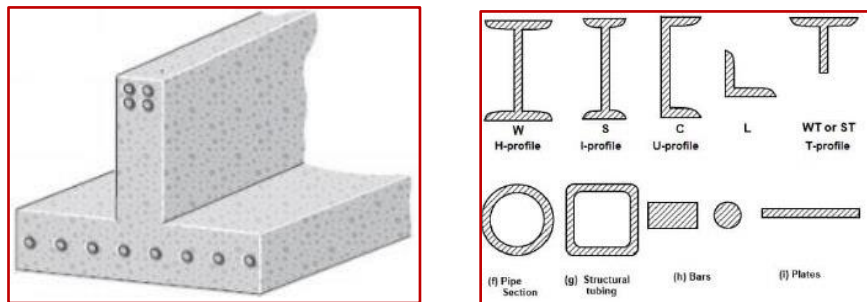


Fig (11) steel beam cross sectional shapes

Based on Geometry

12. Straight beam:

Beam with a straight profile and the majority of beams in structures are straight beams.as shown in Fig. (12).

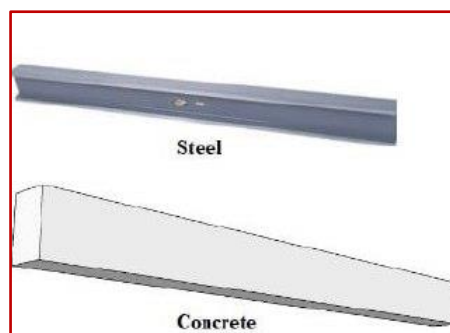


Fig (12) straight beam

13. Curved beam:

Beam with curved profile, such as in the case of circular buildings.as shown in Fig .(13).

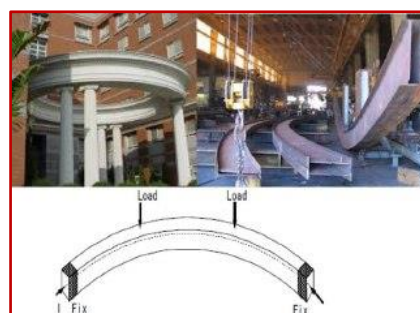


Fig (13) curved beam

14. Tapered beam:

Beam with tapered cross section. As shown in Fig. (14)

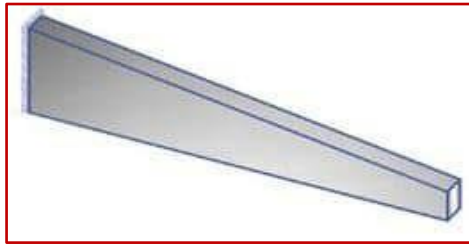


Fig (14) tapered beam

5. Based on Equilibrium Condition

15. Statically Determinate Beam:

For a statically determinate beam, equilibrium conditions alone can be used to solve reactions. The number of unknown reactions is equal to the number of equations. as shown in Fig. (15).

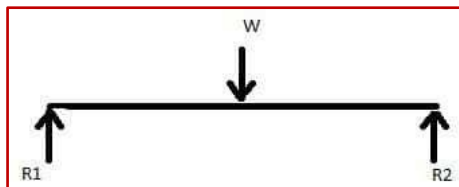


Fig (15) statically determinate beam

16. Statically Indeterminate Beam:

For a statically indeterminate beam, equilibrium conditions are not enough to solve reactions. So, the analysis of this type of beam is more complicated than that of statically determinate beams. As shown in Fig. (16).

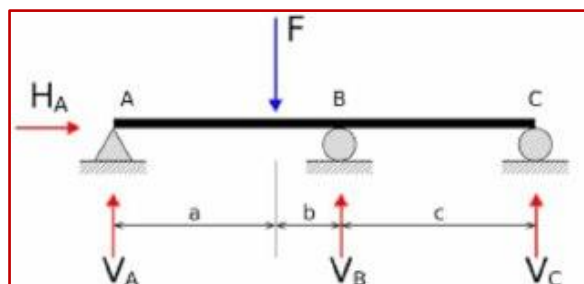


Fig (16) statically indeterminate beam

Based on Method of Construction

17. Cast In-situ Concrete Beam:

This type of beam is constructed on the project site. So, forms are initially fixed, then fresh concrete is poured and allowed to hardened. Then, loads would be imposed. As shown in Fig.(17).



Fig (17) cast in-situ concrete beam

18. Precast Concrete Beam:

This type of beam is manufactured in factories. So, the construction condition is more controllable compare with on-site construction. Consequently, the quality of the concrete of the beam would be greater. Various cross-sectional shapes can be manufactures such as T- beam, Double T- beam, Inverted T-beam, and many more.as shown in Fig. (18).

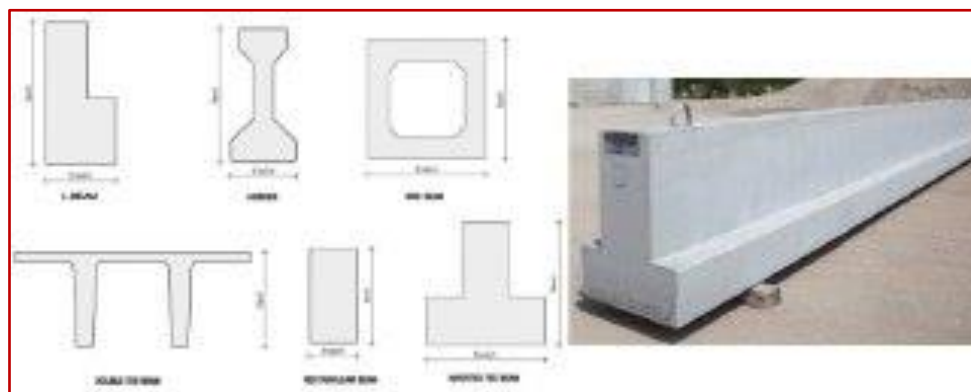


Fig (18) precast concrete beam

19. Pre-stressed Concrete Beam:

The pre-stressed concrete beam is constructed by stressing strands before applying loads on the beam. Pre-tensioned concrete beam and post-tensioned concrete beams are variations of pre-stressed concrete beam.as shown in Fig.(19).



Fig (19) pre-stressed concrete beam

Others:

20. Deep Beam:

A deep beam has considerable depth, as shown in Fig.(21), and its clear span to depth ratio is less than four, as per ACI Code. A substantial load is carried to the supports by a compression force combining the load and the reaction. Consequently, the strain distribution is no longer considered linear, as in the case of conventional beams.



Fig (20) deep beam

21. Girder:

Beams that take heavy loads, generally steel sections are used.as shown in Fig.(21).

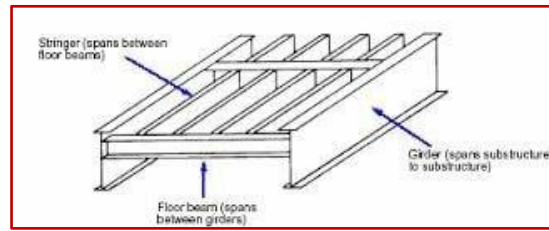


Fig (21) girder

1.4 Deflection of beam:

In engineering, deflection is the degree to which a structural element is displaced under a load (due to its deformation). It may refer to an angle or a distance. The deflection distance of a member under a load can be calculated by integrating the function that mathematically describes the slope of the deflected shape of the member under that load. Standard formulas exist for the deflection of common beam configurations and load cases at discrete locations. Otherwise methods such as virtual work, direct integration, Castigliano's method, Macaulay's method or the direct stiffness method are used. The deflection of beam elements is usually calculated on the method are used. The deflection of beam elements is usually calculated on the basis of the Euler–Bernoulli beam equation while that of a plate or shell element is calculated using plate or shell theory. An example of the use of deflection in this context is in building construction Architects and engineers select materials for various applications.as shown in Fig.(22).

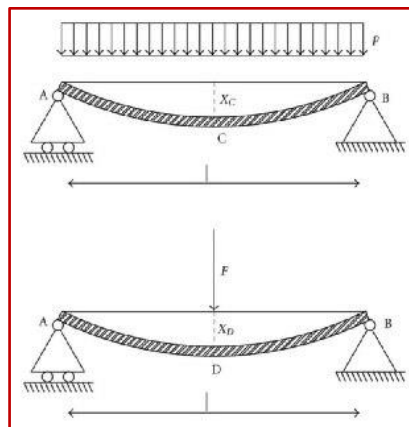


Fig (22) deflection of beam

2

CHAPTER TWO

Deflection of beams

DEFLECTION OF BEAMS

2.1 introduction:

In this chapter, we will learn about deflection, types, and how it is calculated by means of mathematical methods.

2.2 deflection of beams:

Deflection is defined as the vertical displacement of a point on a loaded beam. There are many methods to find out the slope and deflection at a section in a loaded beam. The maximum deflection occurs where slope is zero. The position of the maximum deflection is found out by equating the slope equation zero. Then the value of x is substituted in the deflection equation to calculate the maximum deflection

2.3 deflection calculation methods:

There are several ways to calculate deflection and they are as follows:

- ❖ Double- Integration Method
- ❖ Moment-area method
- ❖ method of superposition
- ❖ slope deflection method

2.3.1 Differential equation of the elastic curve:

As shown, the vertical deflection of A, denoted by v , is considered to be positive if directed in the positive direction of the y -axis - that is, upward in Fig (23 because the axis of the beam lies on the neutral surface, its length does not change. Therefore, the distance, measured along the length does not change. Therefore, the distance, measured along the elastic curve, is also x . It follows that the horizontal deflection of A is negligible provided the slope of the elastic curve remains small.

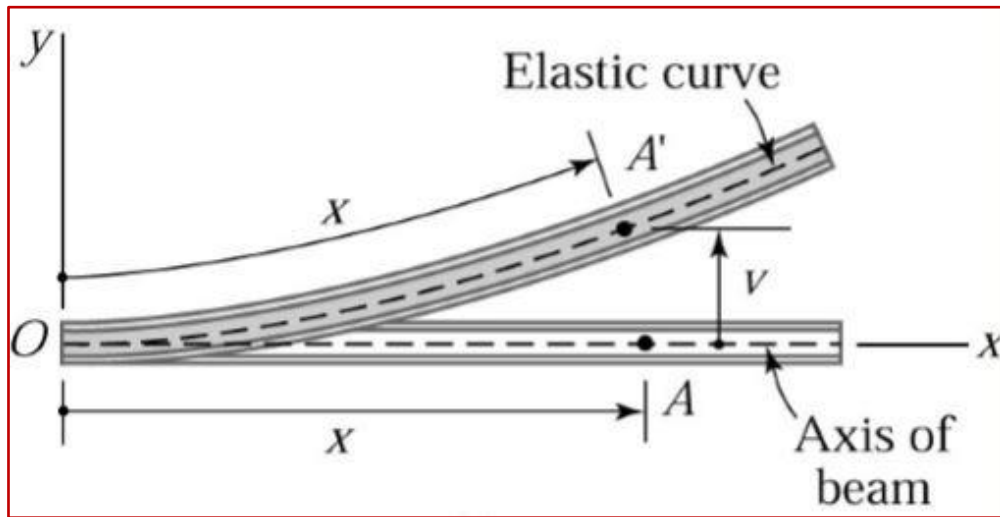


Fig (23) elastic curve

2.3.2 double -integration method:

This is most suitable when concentrated or (udl) over entire length is acting on the beam. The double integration method is a powerful tool in solving deflection and slope of a beam at any point because we will be able to get the equation of the elastic curve.

$$EI \frac{d^2y}{dx^2} = -M$$

Integrating one time $EI \frac{dy}{dx} = -\int M$

Integrating again $EIy = -\iint M$

Where,

M = Bending moment

I = Moment of inertia of the beam section

y = Deflection of the beam

E = Modulus of elasticity of beam material.

2.3.3 Area Moment Method:

The moment-area method is one of the most effective methods for obtaining the bending displacement in beams and frames. In this method, the area of the bending moment diagrams is utilized for computing the slope and or deflections at particular points along the axis of the beam or frame. Two theorems known as the moment area theorems are utilized for calculation of the deflection. One theorem is used to calculate the change

in the slope between two points on the elastic curve. The other theorem is used to compute the vertical distance (called tangential deviation) between a point on the elastic curve and a line tangent to the elastic curve at a second point. Consider Figure. (24) showing the elastic curve of a loaded simple beam. On the elastic curve tangents are drawn on points A and B. Total angle between the two tangents is denoted as $\Delta\theta_{AB}$. In order to find out $\Delta\theta_{AB}$, consider the incremental change in angle $d\theta$ over an infinitesimal segment dx located at a distance of x from point B.

The radius of curvature and bending

moment for any section of the beam is given by the usual bending equation 1

$$1) \frac{M}{I} = \frac{E}{R}$$

where R is the radius of curvature; E is the modulus of elasticity; I is the moment of inertia; and M denotes the bending moment. The elementary length dx and the change in angle $d\theta$ are related as,

$$2) dx = d\theta \times R$$

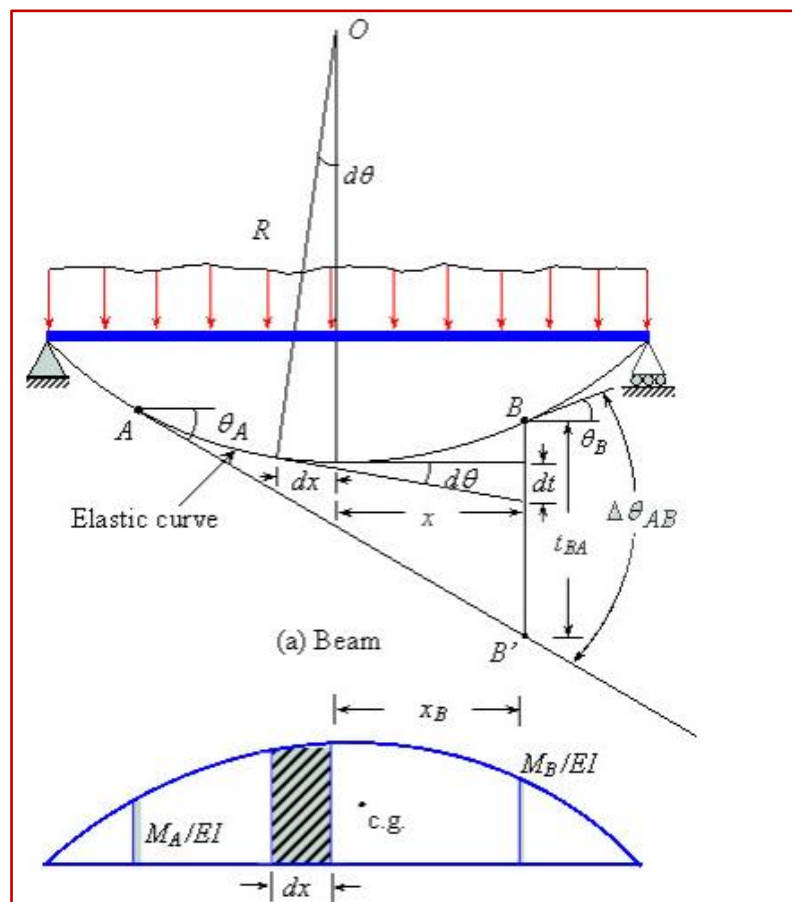


Fig (24) M/EI diagram

Substituting R from Eq. (2) in Eq. (1)

$$3) d_{\theta} = \frac{M}{EI} d_x$$

The total angle change $\Delta\theta_{AB}$ can be obtained by integrating Eq. (4.) between points A and B which is expressed as

$$4) \Delta\theta_{AB} = \int_A^B d_{\theta}$$

Or, $\theta_B - \theta_A = \text{Area of } M / EI \text{ diagram between A and B}$

The difference of slope between any two points on a continuous elastic curve of a beam is equal to the area under the M / EI curve between these points.

The distance d_t along the vertical line through point B is nearly equal to.

$$5) d_t = X \times d_{\theta}$$

Integration of d_t between points A and B yield the vertical distance t_{AB} between the point B and the tangent from point A on the elastic curve. Thus,

$$6) t_{BA} = \int_A^B X d_{\theta} = \int_A^B \frac{M}{EI} X$$

since the quantity Md_x / EI represents an infinitesimal area under the M /EI diagram and distance x from that area to point B, the integral on right hand side of Eq.(6) can be interpreted as moment of the area under the M/EI diagram between points A and B about point B . This is the second moment area theorem If A and B are two points on the deflected shape of a beam, the vertical distance of point B from the tangent drawn to the elastic curve at point A is equal to the moment of bending moment diagram area between the points A and B about the vertical line from point B , divided by EI Sign convention used here can be remembered keeping the simply supported beam of Figure 4.1 in mind. A sagging moment is the positive bending moment diagram and has positive area. Slopes are positive if measured in the anti-clockwise direction. Positive deviation t_{AB} indicates that the point B lies above the tangent from the point A.

2.3.4 Derivation of slope deflection equations:

When a simple beam of length L_{ab} and flexural rigidity $E_{ab}I_{ab}$ is loaded at each end with clockwise moments M_{ab} and M_{ba} , member end rotations occur in the same direction.

These rotation angles can be calculated using the unit force method or Darcy's Law.

$$1) \theta_a - \frac{\Delta}{L_{ab}} = \frac{L_{ab}}{3E_{ab}I_{ab}} M_{ab} - \frac{I_{ab}}{6E_{ab}I_{ab}}$$

$$2) \theta_b - \frac{\Delta}{L_{ab}} = -\frac{L_{ab}}{6E_{ab}I_{ab}} M_{ab} + \frac{L_{ab}}{3E_{ab}I_{ab}}$$

Rearranging these equations, the slope deflection equations are derived.

2.3.5 Slope deflection method:

The slope deflection method is a structural analysis method for beams and frames introduced in 1914 for more than a decade until the moment distribution method was developed. In the book, "The Theory and Practice of Modern Framed Structures", written by J.B Johnson, C.W. Bryan and F.E. Terenure, it is stated that this method was first developed, "by Professor Otto Mohr Many". According to this book, professor Otto Mohr introduced this method for the first time in his book, "Evaluation of Trusses with Rigid Node Connections" or "Die Berechnung der Fachwerke mit Starren Knotenverbindungen".

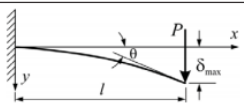
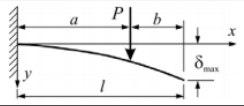
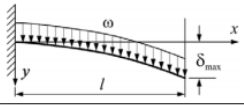
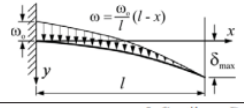
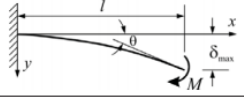
The slope deflection equations can also be written using the stiffness

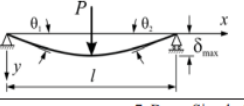
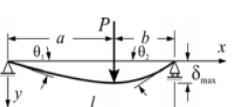
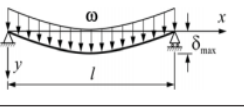
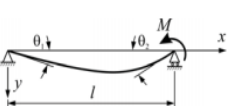
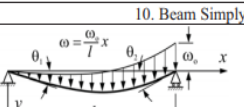
factor $K = \frac{I_{ab}}{L_{ab}}$ and the chord rotation $\psi = \frac{\Delta}{L_{ab}}$

2.3.5.1 Method of Superposition:

The method of superposition, in which the applied loading is represented as a series of simple loads for which deflection formulas are available. Then the desired deflection is computed by adding the contributions of the component loads (principle of superposition). Mostly direct formula is used in questions; hence it is advised to look for the beam deflection formula which are directly asked from this topic rather than going for long derivations.

2.4 Deflection formula:

BEAM DEFLECTION FORMULAE			
BEAM TYPE	SLOPE AT FREE END	DEFLECTION AT ANY SECTION IN TERMS OF x	MAXIMUM DEFLECTION
1. Cantilever Beam – Concentrated load P at the free end			
	$\theta = \frac{Pl^2}{2EI}$	$y = \frac{Px^2}{6EI}(3l-x)$	$\delta_{\max} = \frac{Pl^3}{3EI}$
2. Cantilever Beam – Concentrated load P at any point			
	$\theta = \frac{Pa^2}{2EI}$	$y = \frac{Px^2}{6EI}(3a-x)$ for $0 < x < a$ $y = \frac{Pa^2}{6EI}(3x-a)$ for $a < x < l$	$\delta_{\max} = \frac{Pa^2}{6EI}(3l-a)$
3. Cantilever Beam – Uniformly distributed load ω (N/m)			
	$\theta = \frac{\omega l^3}{6EI}$	$y = \frac{\omega x^2}{24EI}(x^2 + 6l^2 - 4lx)$	$\delta_{\max} = \frac{\omega l^4}{8EI}$
4. Cantilever Beam – Uniformly varying load: Maximum intensity ω_0 (N/m)			
	$\theta = \frac{\omega_0 l^3}{24EI}$	$y = \frac{\omega_0 x^2}{120EI}(10l^3 - 10l^2x + 5lx^2 - x^3)$	$\delta_{\max} = \frac{\omega_0 l^4}{30EI}$
5. Cantilever Beam – Couple moment M at the free end			
	$\theta = \frac{Ml}{EI}$	$y = \frac{Mx^2}{2EI}$	$\delta_{\max} = \frac{Ml^2}{2EI}$

BEAM DEFLECTION FORMULAS			
BEAM TYPE	SLOPE AT ENDS	DEFLECTION AT ANY SECTION IN TERMS OF x	MAXIMUM AND CENTER DEFLECTION
6. Beam Simply Supported at Ends – Concentrated load P at the center			
	$\theta_1 = \theta_2 = \frac{Pl^2}{16EI}$	$y = \frac{Px}{12EI}\left(\frac{3l^2}{4} - x^2\right)$ for $0 < x < \frac{l}{2}$	$\delta_{\max} = \frac{Pl^3}{48EI}$
7. Beam Simply Supported at Ends – Concentrated load P at any point			
	$\theta_1 = \frac{Pb(l^2 - b^2)}{6EI}$ $\theta_2 = \frac{Pab(2l - b)}{6EI}$	$y = \frac{Pbx}{6EI}(l^2 - x^2 - b^2)$ for $0 < x < a$ $y = \frac{Pb}{6EI}\left[\frac{l}{b}(x-a)^3 + (l^2 - b^2)x - x^3\right]$ for $a < x < l$	$\delta_{\max} = \frac{Pb(l^2 - b^2)^{3/2}}{9\sqrt{3}EI}$ at $x = \sqrt{(l^2 - b^2)/3}$ $\delta = \frac{Pb}{48EI}(3l^2 - 4b^2)$ at the center, if $a > b$
8. Beam Simply Supported at Ends – Uniformly distributed load ω (N/m)			
	$\theta_1 = \theta_2 = \frac{\omega l^3}{24EI}$	$y = \frac{\omega x}{24EI}(l^3 - 2lx^2 + x^3)$	$\delta_{\max} = \frac{5\omega l^4}{384EI}$
9. Beam Simply Supported at Ends – Couple moment M at the right end			
	$\theta_1 = \frac{Ml}{6EI}$ $\theta_2 = \frac{Ml}{3EI}$	$y = \frac{Mlx}{6EI}\left(1 - \frac{x^2}{l^2}\right)$	$\delta_{\max} = \frac{Ml^2}{9\sqrt{3}EI}$ at $x = \frac{l}{\sqrt{3}}$ $\delta = \frac{Ml^2}{16EI}$ at the center
10. Beam Simply Supported at Ends – Uniformly varying load: Maximum intensity ω_0 (N/m)			
	$\theta_1 = \frac{7\omega_0 l^3}{360EI}$ $\theta_2 = \frac{\omega_0 l^3}{45EI}$	$y = \frac{\omega_0 x}{360EI}(7l^4 - 10l^2x^2 + 3x^4)$	$\delta_{\max} = 0.00652 \frac{\omega_0 l^4}{EI}$ at $x = 0.519l$ $\delta = 0.00651 \frac{\omega_0 l^4}{EI}$ at the center

3

CHAPTER THREE

Programming by using Q basic

Programming BY Using Q basic

3.1 Introduction:

In this chapter, we will learn about programming, its history, stages of development and its importance in facilitating mathematical operations in engineering in all specialties.

3.2 Computer Programming:

Computer programming (often shortened to programming or coding is the process of designing, writing, testing, debugging / troubleshooting ? and maintaining the source code of computer programs, this source code is written in programming language; the purpose of programming is to create a program that exhibits certain desired behavior .The process of writing source code often requires expertise in many different subjects, including knowledge of the application domain, specialized algorithms and formal logic.

3.3 History of Programming:

Programmable devices have existed for centuries. As early as the 9th century, a programmable music sequencer was invented by the Persian Banu Musa brothers, who described an automated mechanical flute player in the Book of Ingenious Devices. In 1206, the Arab engineer Al-Jazari invented a programmable drum machine where musical mechanical automaton could be made to play different rhythms and drum patterns, via pegs and cams. In 1801, the Jacquard loom could produce entirely different weaves by changing the "program" – a series of pasteboard cards with holes punched in them.

Code-breaking algorithms have also existed for centuries. In the 9th century, the Arab mathematician Al-Kindi described a cryptographic algorithm for deciphering encrypted code, in A Manuscript on Deciphering Cryptographic Messages. He gave the first description of cryptanalysis by frequency analysis, the earliest code-breaking algorithm. The first computer program is generally dated to 1843, when mathematician Ada Lovelace published an algorithm to calculate a sequence of Bernoulli numbers, intended to be carried out by Charles Babbage's Analytical Engine.

Data and instructions were once stored on external punched cards, which were kept in order and arranged in program decks.

In the 1880s Herman Hollerith invented the concept of storing data in machine-readable form. Later a control panel (plugboard) added to his 1906 Type I Tabulator allowed it to be programmed for different jobs, and by the late 1940s, unit record equipment such as the IBM 602 and IBM 604, were programmed by control panels in a similar way; as were the first electronic computers. However, with the concept of the stored-program computers introduced in 1949, both programs and data were stored and manipulated in the same way in computer memory. [citation needed]

Machine code was the language of early programs, written in the instruction set of the particular machine, often in binary notation. Assembly languages were soon developed that let the programmer specify instruction in a text format, (e.g., ADD X, TOTAL), with abbreviations for each operation code and meaningful names for specifying addresses. However, because an assembly language is little more than a different notation for a machine language, any two machines with different instruction sets also have different assembly languages.

Wired control panel for an IBM 402 Accounting Machine. High-level languages made the process of developing a program simpler and more understandable, and less bound to the underlying hardware. FORTRAN, the first widely used high-level language to have a functional implementation, came out in 1957[10] and many other languages were soon developed – in particular, COBOL aimed at commercial data processing, and Lisp for computer research.

Programs were mostly still entered using punched cards or paper tape. See computer programming in the punch card era. By the late 1960s, data storage devices and computer terminals became inexpensive enough that programs could be created by typing directly into the computers. Text editors (programs themselves) were developed that allowed changes and corrections to be made much more easily than with punched cards.

3.4 modern Programming:

Whatever the approach to development may be, the final program must satisfy some fundamental properties. The following properties are among the most important:

- ❖ **Reliability:** how often the results of a program are correct. This depends on conceptual correctness of algorithms, and minimization of programming mistakes,

such as mistakes in resource management (e.g., buffer overflows and race conditions) and logic errors (such as division by zero or off-by-one errors).

- ❖ **Robustness**: how well a program anticipates problems due to errors (not bugs). This includes situations such as incorrect, inappropriate or corrupt data, unavailability of needed resources such as memory, operating system services and network connections, user error, and unexpected power outages.
- ❖ **Usability**: the ergonomics of a program: the ease with which a person can use the program for its intended purpose or in some cases even unanticipated purposes. Such issues can make or break its success even regardless of other issues. This involves a wide range of textual, graphical and sometimes hardware elements that improve the clarity, intuitiveness, cohesiveness and completeness of a program's user interface.
- ❖ **Portability**: the range of computer hardware and operating system platforms on which the source code of a program can be compiled/interpreted and run. This depends on differences in the programming facilities provided by the different platforms, including hardware and operating system resources, expected behavior of the hardware and operating system, and availability of platform specific compilers (and sometimes libraries) for the language of the source code.
- ❖ **Maintainability**: the ease with which a program can be modified by its present or future developers in order to make improvements or customizations, fix bugs and security holes, or adapt it to new environments. Good practices during initial development make the difference in this regard. This quality may not be directly apparent to the end user but it can significantly affect the fate of a program over the long term.
- ❖ **Efficiency/performance**: Measure of system resources a program consumes (processor time, memory space, slow devices such as disks, network bandwidth and to some extent even user interaction): the less, the better. This also includes careful management of resources, for example cleaning up temporary files and eliminating memory leaks.

3.5 Readability of source code:

In computer programming, readability refers to the ease with which a human reader can comprehend the purpose, control flow, and operation of source code. It affects the aspects of quality above, including portability, usability and most importantly maintainability.

Readability is important because programmers spend the majority of their time reading, trying to understand and modifying existing source code, rather than writing new source code. Unreadable code often leads to bugs, inefficiencies, and duplicated code. A study found that a few simple readability transformations made code shorter and drastically reduced the time to understand it.

Following a consistent programming style often helps readability. However, readability is more than just programming style. Many factors, having little or nothing to do with the ability of the computer to efficiently compile and execute the code, contribute to readability.^[12] Some of these factors include:

- Different indent styles (whitespace)
- Comments
- Decomposition
- Naming conventions for objects (such as variables, classes, procedures, etc.)

The presentation aspects of this (such as indents, line breaks, color highlighting, and so on) are often handled by the source code editor, but the content aspects reflect the programmer's talent and skills.

Various visual programming languages have also been developed with the intent to resolve readability concerns by adopting non-traditional approaches to code structure and display. Integrated development environments (IDEs) aim to integrate all such help.

Techniques like Code refactoring can enhance readability.

3.6 Q basic program:

QBASIC programming language, which is one of the easy to learn languages for beginners. QBASIC stands for “Quick Beginners All-Purpose Symbolic Instruction Code .”

QBASIC was developed by Microsoft Corporation in the year 1991. It is considered to be one of the most easy-to-understand programming languages for beginners. It is suitable

for both mathematical and business problem solving and it has been adopted by most of the microcomputers .

QBASIC is a replacement of the GWBASIC (Greg Whitten – BASIC). It was based on the Quick BASIC 4.5 compiler. QBASIC is only compatible with MS-DOS Environment on windows, it usually contains two files: 1.QBASIC.EXE and QBASIC.HLP. These two files help us to debug, edit and execute code in the DOS environment. QBASIC doesn't produce a .exe file, the files are saved with .bas extension.

3.6.1 History of Q basic:

QBasic was intended as a replacement for GW-BASIC. It was based on the earlier QuickBASIC 4.5 compiler but without QuickBASIC's compiler and linker elements. Version 1.0 was shipped together with MS-DOS 5.0 and higher, as well as Windows 95, Windows NT 3.x, and Windows NT 4.0. IBM recompiled QBasic and included it in PC DOS 5.x, as well as OS/2 2.0 onwards. eComStation, descended from OS/2 code, includes QBasic 1.0 . QBasic 1.1 is included with MS-DOS 6.x, and, without EDIT, in Windows 95, Windows 98 and Windows Me. Starting with Windows 2000, Microsoft no longer includes QBasic with their operating systems, but can still be obtained for use on newer versions of Windows.

QBasic (as well as the built-in MS-DOS Editor) is backwards-compatible with DOS releases prior to 5.0 (down to at least DOS 3.20). However, if used on any 8088/8086 computers, or on some 80286 computers, the QBasic program may run very slowly, or perhaps not at all, due to DOS memory size limits. Until MS-DOS 7, MS-DOS Editor and Help required QBasic: the EDIT.COM and HELP.COM programs simply started QBasic in editor and help mode only, and these can also be entered by running QBASIC.EXE with the /EDITOR and /QHELP switches (i.e., command lines QBASIC /EDITOR and QBASIC /QHELP)

3.6.2 Advantages and Disadvantages:

Some of the advantages of QBasic are:

- QBasic is very easy-to-learn programming language.
- QBasic is free to download and it comes pre-installed in Windows 95/98.

- Suitable for mathematical and business applications.
- Best for beginners to understand the programming language.
- It checks for errors in syntax automatically.
- It is simple and easy to debug.

And some of the disadvantages of QBasic are:

- QBasic is not a well-structured programming language.
- It is mostly used in education or training.
- QBasic does not contain a compiler, and cannot generate executable programs.
- It is not a professional language.

3.7Flowchart:

3.7.1 introduction:

A flowchart is a type of diagram that represents a workflow or process. A flowchart can also be defined as a diagrammatic representation of an algorithm, a step-by-step approach to solving a task.

The flowchart shows the steps as boxes of various kinds, and their order by connecting the boxes with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields

3.7.2 Types of flowcharts:

Stern Eckert (2003) suggested that flowcharts can be modeled from the perspective of different user groups (such as managers, system analysts and clerks), and that there are four general types:

- Document flowcharts, showing controls over a document-flow through a system.
- Data flowcharts, showing controls over a data-flow in a system.
- System flowcharts, showing controls at a physical or resource level.
- Program flowchart, showing the controls in a program within a system.

Notice that every type of flowchart focuses on some kind of control, rather than on the particular flow itself.

However, there are some different classifications. For example, Andrew Veronis (1978) named three basic types of flowcharts: the system flowchart, the general flowchart, and the detailed flowchart. That same year Marilyn Bohl (1978) stated "in practice, two kinds of flowcharts are used in solution planning: system flowcharts and program flowcharts...". More recently, Mark A. Fryman (2001) identified more differences: "Decision flowcharts, logic flowcharts, systems flowcharts, product flowcharts, and process flowcharts are just a few of the different types of flowcharts that are used in business and government".

In addition, many diagram techniques are similar to flowcharts but carry a different name, such as UML activity diagrams.

3.7.3 Flowcharts tools:

There are some symbols that make up of most flow charts:

- ☐ Elongate circles, which signify the start or end of a process .



START

- ☐ Rectangles, which show instruction or actions .



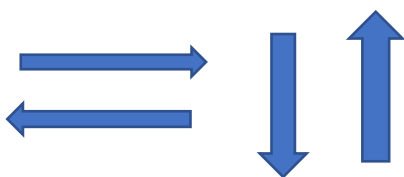
PRINT

- ☐ Diamonds, which show decisions that, must be made .



IF

- ☐ Flow line, Shows directions of flow.



3.8 RESULTS :

3.8.1 introduction:

1-The first step: Initially, when programming a program using Q basic, determining the work that we do for it, for example, equations or numbers, and any entries inside the program in order to facilitate the user's work, and therefore Q basic allowed us to command REM

2- The second step: After using the REM command, we learned about the type of program being used and the work it is doing now. We move on to the second stage, which uses INPUT. This command means all the inputs needed to use the program from entering it in the written equations inside the program and giving the necessary results through specific programming and several commands.

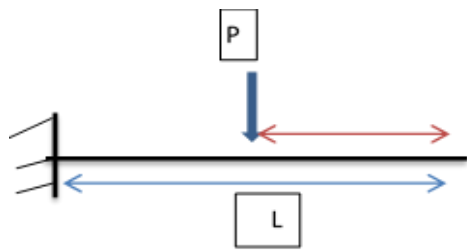
3- The third step: After entering all the program inputs, we will move to the most important stage in the program, which is programming, where program orders are used depending on the formula of the required equations. For example, in our program used to calculate deformation in thresholds, there are many different inputs and equations for this. We know the programming formula for this type of equation with the pictures shown. As follows.

3.8.2 Q basic programming to calculate deflection of all beams:

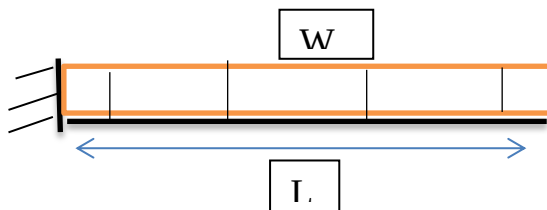
In this step, as mentioned earlier, we defined the types of beams in which we want to calculate the distortion, so we used the REM command and wrote each type at a special point

1- cantilever beam (concentrated load at free end)





2- cantilever beam (concentrated load at any point)



3- cantilever beam (uniformly distributed load)

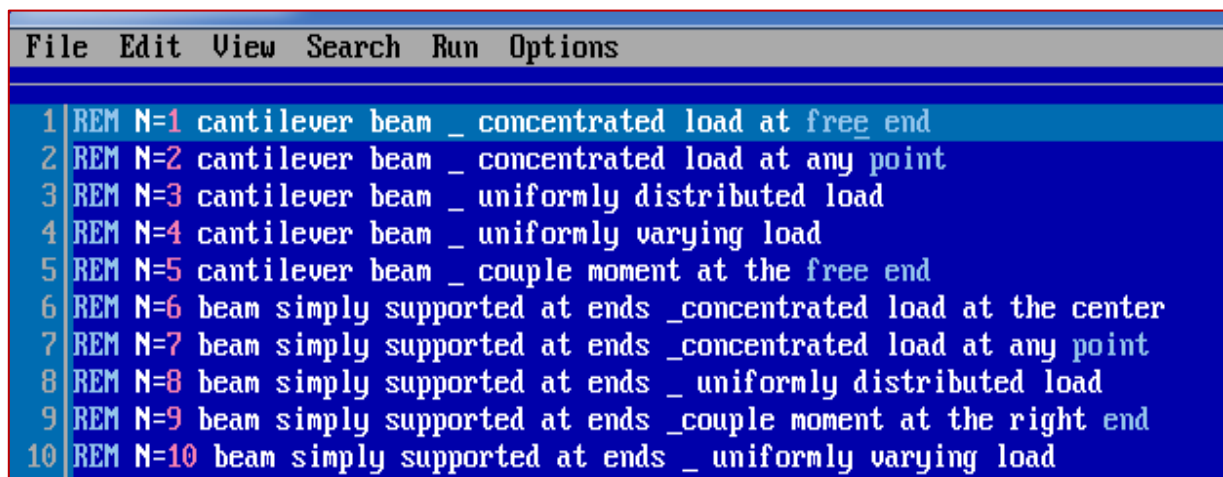
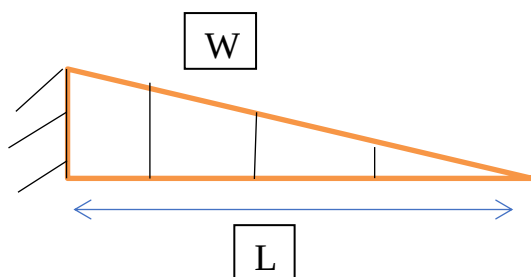
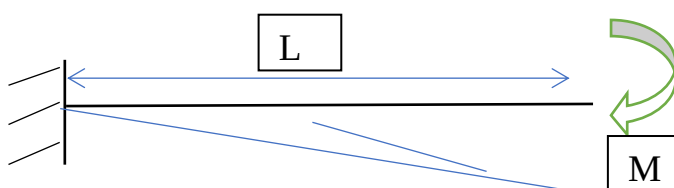


Image of program

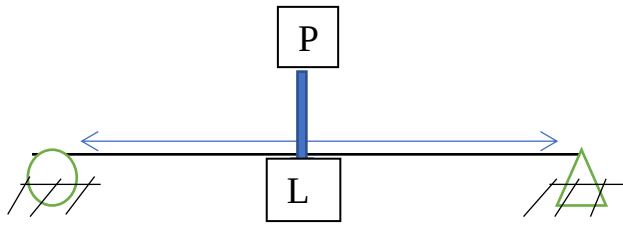
4- cantilever beam (uniformly varying load)



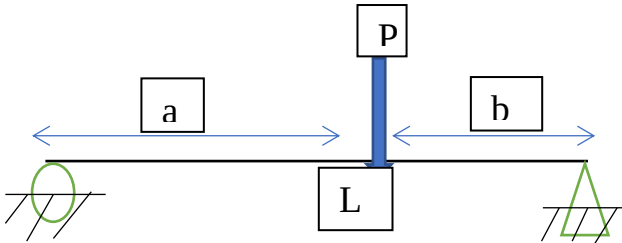
5- cantilever beam (couple moment)



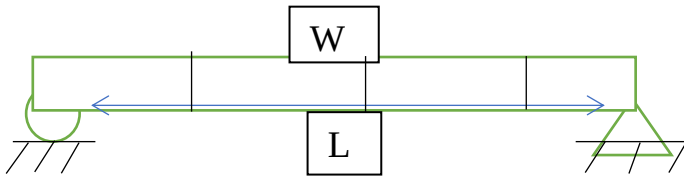
6- beam simply supported at ends (concentrated load at the center).



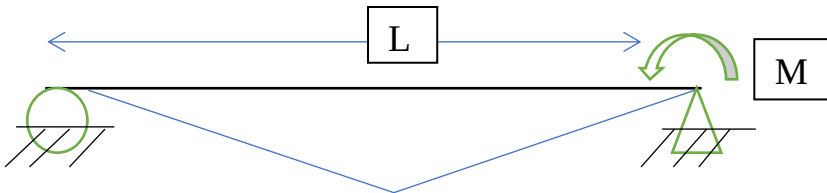
7- beam simply supported at ends (concentrated load at any point).



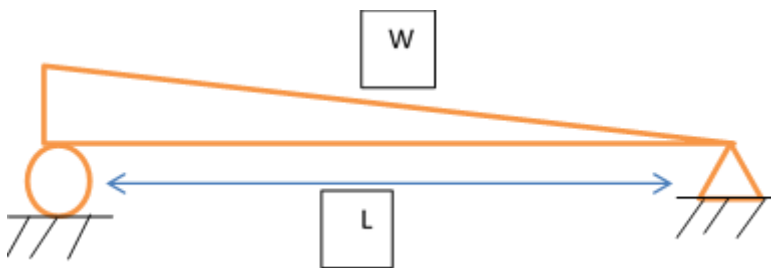
8- beam simply supported at ends (uniformly distributed load).



9- beam simply supported at ends (couple moment).



10- beam simply supported at ends (uniformly varying load).



After specifying all the beams that have been entered into the program in order to calculate the distortion, we move to the programming stage and create a loop for the program which is as shown in the image below:

```

11 INPUT N
12 IF N = 1 THEN
13     INPUT " the concentrated load P(KN)"; P
14     INPUT " the lenght of beam L(M)"; L
15     INPUT "modulus of elastisty E(KN/M^2)"; E
16     INPUT "moment of inertia I (M^4)"; I
17     FOR X = 0 TO L STEP (L / 10)
18         Y = ((P * X ^ 2) / (6 * E * I) * (3 * L - X)) * 1000
19         PRINT "X= "; X; "Y= "; Y
20     NEXT
21 ELSE
22 END IF
23 IF N = 2 THEN
24     INPUT " the concentrated load P(KN)"; P
25     INPUT " the lenght of beam L(M)"; L
26     INPUT "modulus of elastisty E(KN/M^2)"; E
27     INPUT "moment of inertia I (M^4)"; I
28     INPUT " distance from support to load a"; a
29     FOR X = 0 TO L STEP (L / 10)
30         IF X < a THEN
31             Y = ((P * X ^ 2) / (6 * E * I) * (3 * a - X)) * 1000
32             PRINT "X= "; X; "Y= "; Y
33         ELSE
34             Y = ((P * a ^ 2) / (6 * E * I) * (3 * X - a)) * 1000
35             PRINT "X= "; X; "Y= "; Y
36         END IF
37     NEXT
38 ELSE
39 END IF

```

Image of program

```

File Edit View Search Run Options
Untitled*
40 IF N = 3 THEN
41     INPUT " the distributed load W(KN/M)"; W
42     INPUT " the lenght of beam L(M)"; L
43     INPUT "modulus of elastisty E(KN/M^2)"; E
44     INPUT "moment of inertia I (M^4)"; I
45     FOR X = 0 TO L STEP (L / 10)
46         Y = ((W * X ^ 2) / (24 * E * I) * (X ^ 2 + 6 * L ^ -4 * L * X)) * 1000
47         PRINT "X= "; X; "Y= "; Y
48     NEXT
49 ELSE
50 END IF
51 IF N = 4 THEN
52     INPUT " the distributed load W(KN/M)"; W
53     INPUT " the lenght of beam L(M)"; L
54     INPUT "modulus of elastisty E(KN/M^2)"; E
55     INPUT "moment of inertia I (M^4)"; I
56     FOR X = 0 TO L STEP (L / 10)
57         Y = ((W * X ^ 2) / (120 * L * E * I) * (10 * L ^ 3 - 10 * L ^ 2 * X + 5 * L * X ^ 2 - X ^ 3)) * 1000
58         PRINT "X= "; X; "Y= "; Y
59     NEXT
60 ELSE
61 END IF
62 IF N = 5 THEN
63     INPUT " the couple moment M(KN*M)"; M
64     INPUT "modulus of elastisty E(KN/M^2)"; E
65     INPUT "moment of inertia I (M^4)"; I
66     FOR X = 0 TO L STEP (L / 10)
67         Y = ((M * X ^ 2) / (2 * E * I)) * 1000
68         PRINT "X= "; X; "Y= "; Y
69     NEXT
70 ELSE
71 END IF

```

Image of program

```

72 IF N = 6 THEN
73   INPUT " the concentrated load P(KN)"; P
74   INPUT " the lenght of beam L(M)"; L
75   INPUT "modulus of elastisty E(KN/M^2)"; E
76   INPUT "moment of inertia I (M^4)"; I
77   FOR X = 0 TO L STEP (L / 10)
78     Y = ((P * X) / (12 * E * I) * (3 * L ^ 2 / 4 - X ^ 2)) * 1000
79     PRINT "X= "; X; "Y= "; Y
80   NEXT
81 ELSE
82 END IF
83 IF N = 7 THEN
84   INPUT " the concentrated load P(KN)"; P
85   INPUT " the lenght of beam L(M)"; L
86   INPUT "modulus of elastisty E(KN/M^2)"; E
87   INPUT "moment of inertia I (M^4)"; I
88   INPUT "the distance from load to right support"; b
89   INPUT " the distance from load to left support "; a
90   FOR X = 0 TO L STEP (0.05)
91     IF X < a THEN
92       Y = ((P * b * X) / (6 * L * E * I) * (L ^ 2 - X ^ 2 - b ^ 2)) * 1000
93       PRINT "X= "; X; "Y= "; Y
94     ELSE
95       Y = ((P * b) / (6 * L * E * I) * (1 / b * (X - a) ^ 3 + (L ^ 2 - b ^ 2) * X - X ^ 3)) * 100
96       PRINT "X= "; X; "Y= "; Y
97     END IF
98   NEXT
99 ELSE
100 END IF
101 IF N = 8 THEN
102   INPUT " the distributed load W(KN/M)"; W
103   INPUT " the lenght of beam L(M)"; L
104   INPUT "modulus of elastisty E(KN/M^2)"; E
105   INPUT "moment of inertia I (M^4)"; I
106   FOR X = 0 TO L STEP (L / 10)
107     Y = ((W * X) / (24 * E * I) * (L ^ 3 - 2 * L * X ^ 2 + X ^ 3)) * 1000
108     PRINT "X= "; X; "Y= "; Y
109   NEXT
110 ELSE
111 END IF

```

Image of program

```

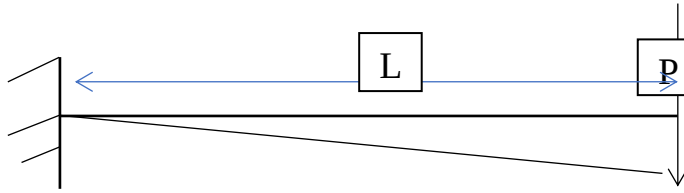
112 IF N = 9 THEN
113   INPUT " the couple moment M(KN*M)"; M
114   INPUT "modulus of elastisty E(KN/M^2)"; E
115   INPUT "moment of inertia I (M^4)"; I
116   INPUT " the lenght of beam L(M)"; L
117   FOR X = 0 TO L STEP (L / 10)
118     Y = ((M * L * X) / (6 * E * I) * (1 - X ^ 2 / L ^ 2)) * 1000
119     PRINT "X= "; X; "Y= "; Y
120   NEXT
121 ELSE
122 END IF
123 IF N = 10 THEN
124   INPUT " the distributed load W(KN/M)"; W
125   INPUT " the lenght of beam L(M)"; L
126   INPUT "modulus of elastisty E(KN/M^2)"; E
127   INPUT "moment of inertia I (M^4)"; I
128   FOR X = 0 TO L STEP (L / 10)
129     Y = ((W * X) / (360 * L * I * E) * (7 * L ^ 4 - 10 * L ^ 2 * X ^ 2 + 3 * X ^ 4)) * 1000
130     PRINT "X= "; X; "Y= "; Y
131   NEXT
132 ELSE
133 END IF

```

Image of program

3.8.3 Solved examples using deformation equations:

Example 1: the cantilever beam shown in fig is 3m long and loaded by an end force of 20 KN. the cross section is a W203 × 59 steel section it has $I = 60.7 \times 10^{-6} \text{ m}^4$ find the maximum deflection of the beam. take $E = 200 \text{ GPa}$.



Solution:

$$y_{\max} = -\frac{PL^3}{3EI}$$

$$y_{\max} =$$

$$\frac{(20000)(3)^3}{3(200 \times 10^9)(60.7 \times 10^{-6})} = -0.0148 \text{ m or } 14.8 \text{ mm}$$

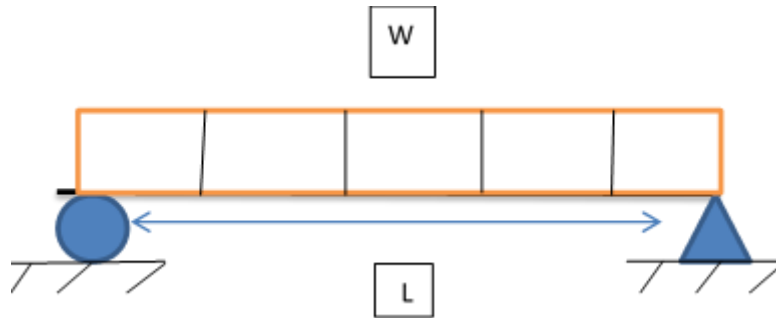
Example 2: A simply supported beam of length 10 ft and rectangular cross section 10 in × 3 in carries uniform load of 200 lb/ft. The beam is titanium, the modulus of elasticity 16×10^6 . Determine the maximum deflection of the beam.

Solution:

$$y_{\max} = \frac{5wl^4}{384EI}$$

$$y_{\max} = \frac{5 \left(\frac{200}{12}\right)(120)^4}{384(16 \times 10^6) \left(\frac{1}{12}\right)(1)(3)^3} = 1.25 \text{ in or } 0.03175 \text{ m}$$

Example 3: A simply supported beam of length 1.5m and the rectangular cross section $50 \times 100 \text{ mm}$ and $P = 20 \text{ KN}$ with $a = 1\text{m}$ $b = 0.5 \text{ m}$. Determine the maximum deflection of the beam take $E = 200 \text{ Gpa}$



Solution:

$$y_{max} = \frac{p b^2 \sqrt{3}}{27 L E I} (L^2 - b^2)^{\frac{3}{2}}$$

$$y_{max} = \frac{20 \times 10^3 (0.5 \times 10^3) [(1.5 \times 10^3)^2 - (0.5 \times 10^3)]^{\frac{3}{2}} (\sqrt{3})(10)^6}{27 (1.5 \times 10^3)(4.167 \times 10^6)(200 \times 10^9)} = -1.45 \text{ mm}$$

3.8.4 Solved examples by using program:

We will use the same examples solved by equations, but apply them in the program as follows:

Example 1:

1-Input

(N, E , I, L , P)

N=t is a number representing the status of the beams identified in the (1) program

E= modulus of elasticity ($200000000 \frac{\text{KN}}{\text{M}^2}$)

I= moment of inertia (0.0000607 M^4)

L= length of beam (3 M)

P= concentrated load (20KN)

2- Run

The results are shown as follows:

```

? 1
the concentrated load P(KN)? 20
the lenght of beam L(M)? 3
modulus of elastisty E(KN/M^2)? 200000000
moment of inertia I (M^4)? 0.0000607
X= 0 Y= 0
X= .3 Y= .2149918
X= .6 Y= .830313
X= .9 Y= 1.801483
X= 1.2 Y= 3.08402
X= 1.5 Y= 4.633443
X= 1.8 Y= 6.405272
X= 2.1 Y= 8.355024
X= 2.4 Y= 10.43822
X= 2.7 Y= 12.61038
X= 3 Y= 14.82702
Press any key to continue
    
```

Image of program

Example 2:

1-Input

N=8

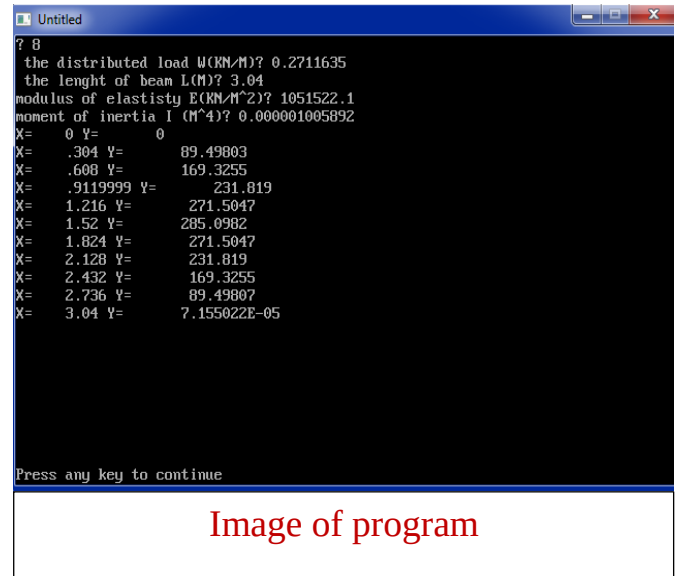
W= (the uniformly load) = 0.2711635 KN/M

$E=1051522.1 \frac{KN}{M^2}$

$I=0.000001005892 M^4$

L= 3.04 M

2- Run



```
? 8
the distributed load W(KN/M)? 0.2711635
the lenght of beam L(M)? 3.04
modulus of elastisty E(KN/M^2)? 1051522.1
moment of inertia I (M^4)? 0.000001005892
X= 0 Y= 0
X= .304 Y= 89.49803
X= .608 Y= 169.3255
X= .9119999 Y= 231.819
X= 1.216 Y= 271.5047
X= 1.52 Y= 285.0982
X= 1.824 Y= 271.5047
X= 2.128 Y= 231.819
X= 2.432 Y= 169.3255
X= 2.736 Y= 89.49807
X= 3.04 Y= 7.155022E-05

Press any key to continue
```

Image of program

Example3:

1-Input

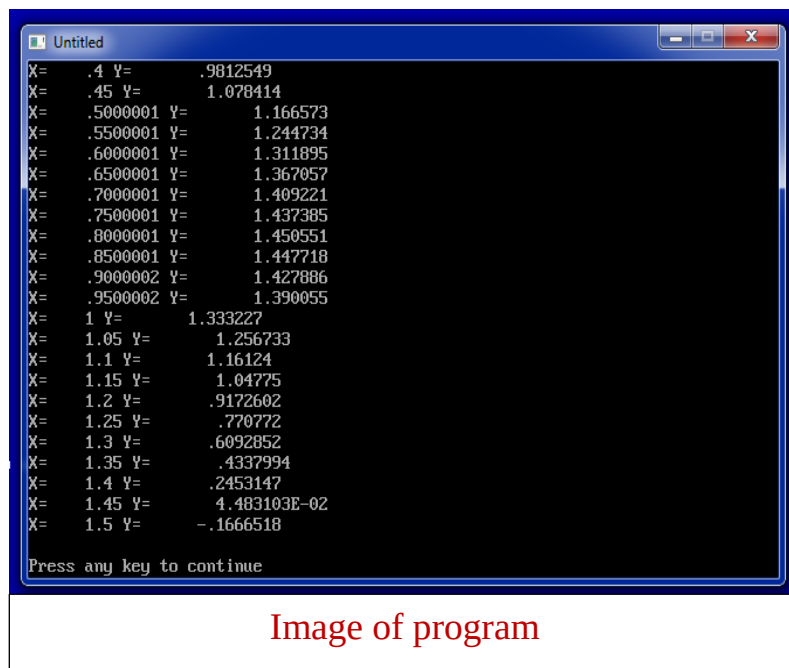
N= 7

P= 20KN

$E= 200000000 \frac{KN}{M^2}$

$I= 0.00000416 M^4$

L= 1.5 M



```
Untitled
X= .4 Y= .9812549
X= .45 Y= 1.078414
X= .5000001 Y= 1.166573
X= .5500001 Y= 1.244734
X= .6000001 Y= 1.311895
X= .6500001 Y= 1.367057
X= .7000001 Y= 1.409221
X= .7500001 Y= 1.437385
X= .8000001 Y= 1.450551
X= .8500001 Y= 1.447718
X= .9000002 Y= 1.427886
X= .9500002 Y= 1.390055
X= 1 Y= 1.333227
X= 1.05 Y= 1.256733
X= 1.1 Y= 1.16124
X= 1.15 Y= 1.04775
X= 1.2 Y= .9172602
X= 1.25 Y= .770772
X= 1.3 Y= .6092852
X= 1.35 Y= .4337994
X= 1.4 Y= .2453147
X= 1.45 Y= 4.483103E-02
X= 1.5 Y= -.1666518

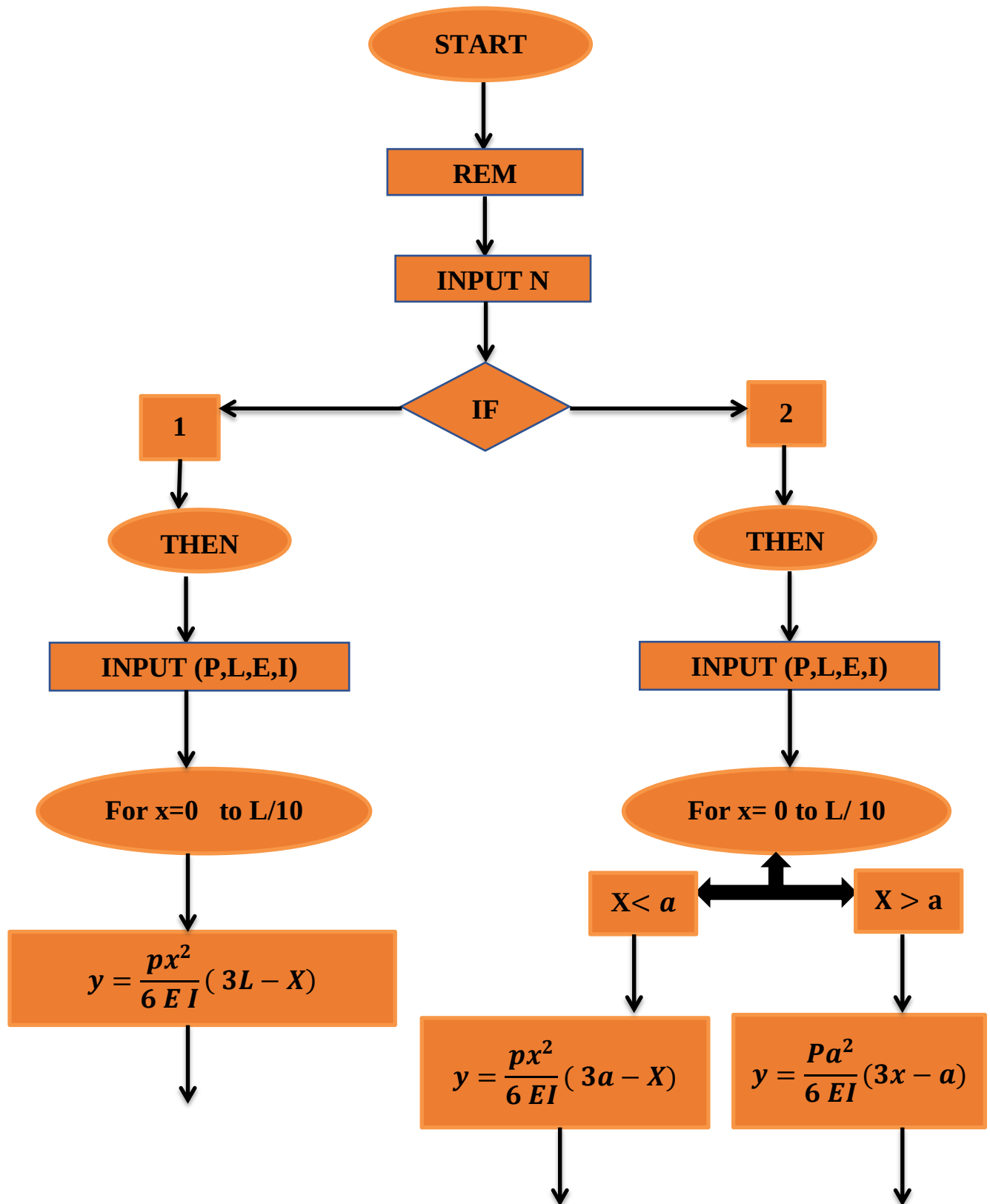
Press any key to continue
```

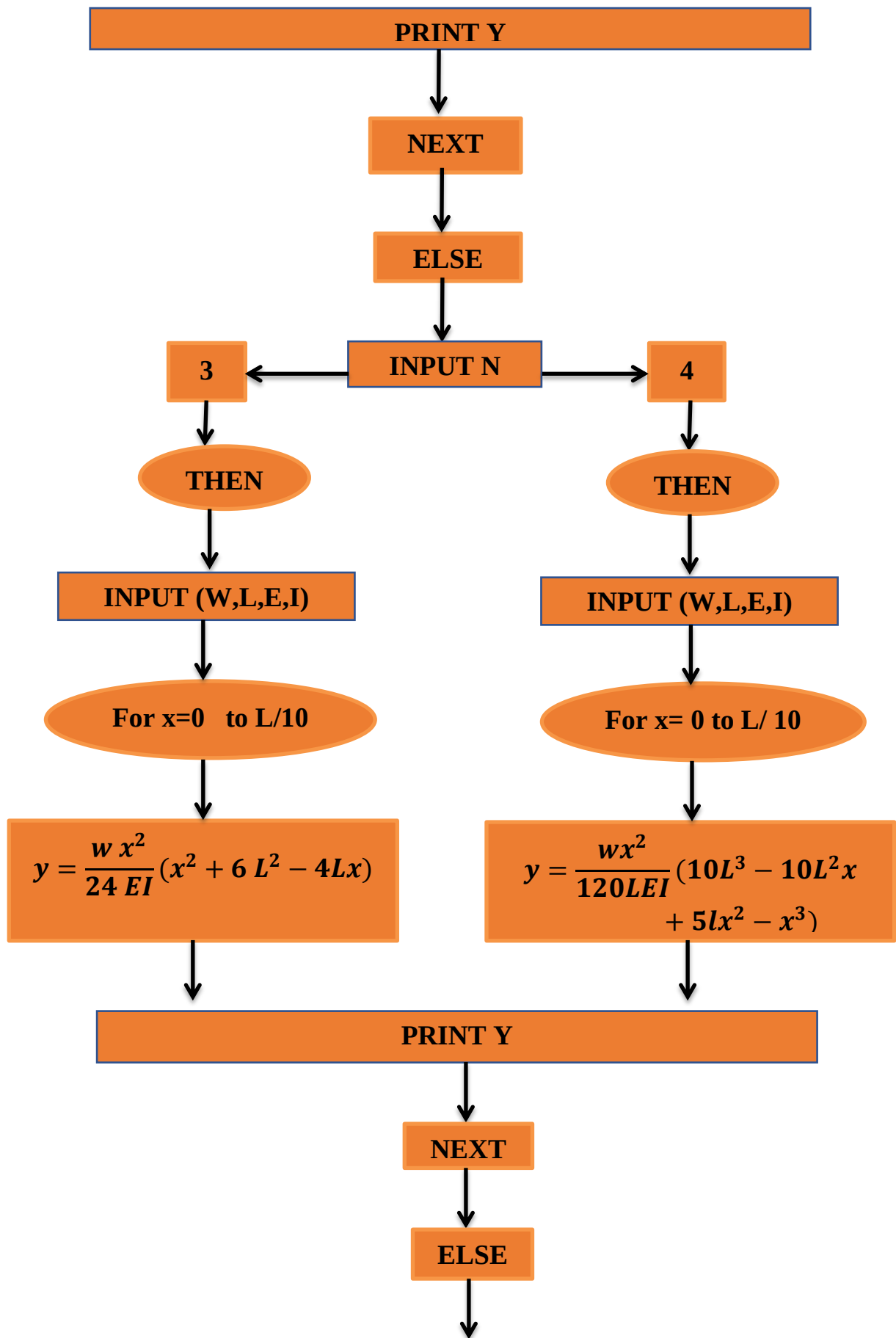
Image of program

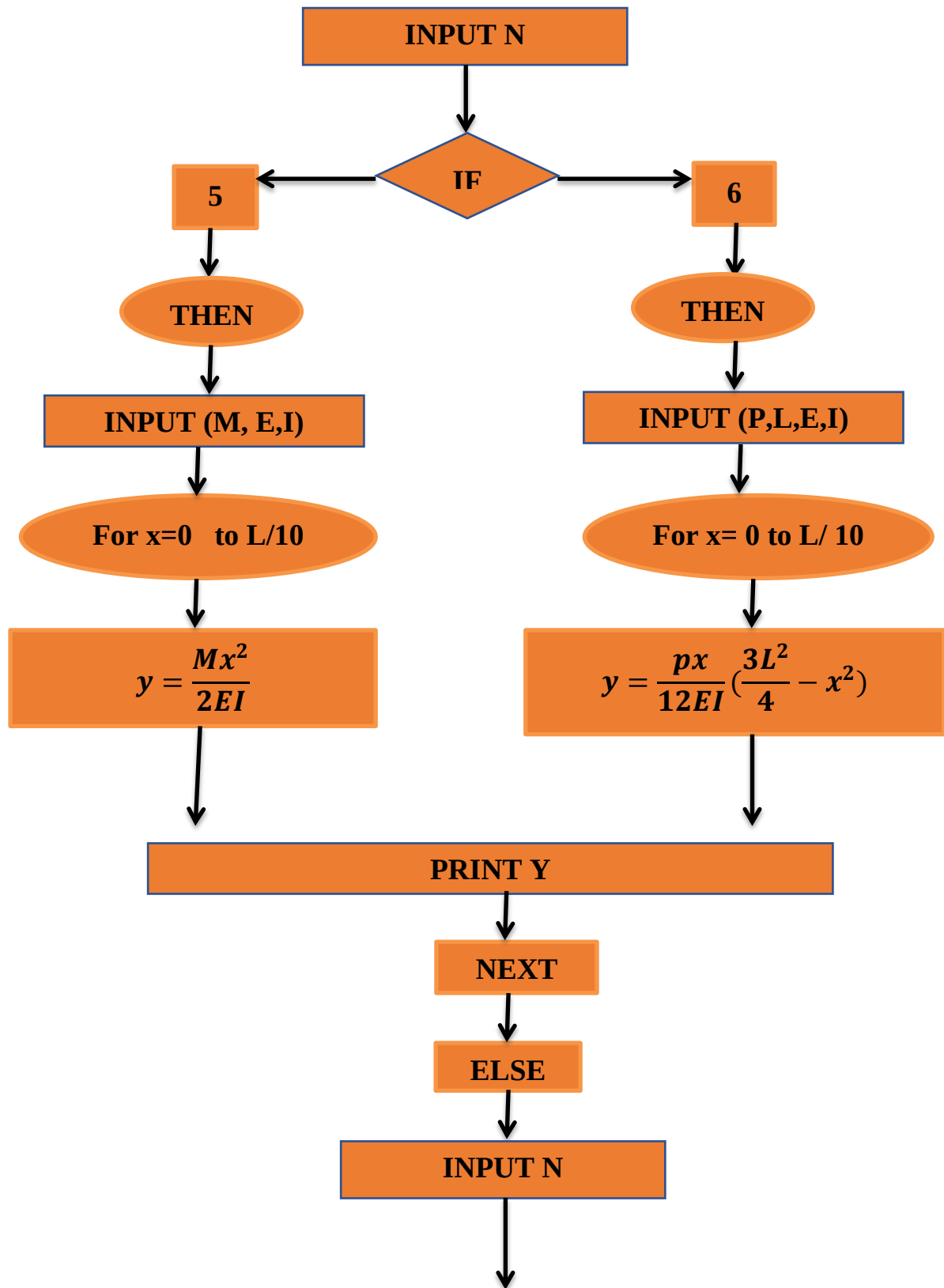
3.8.5 Compare the results from the Theoretical equations and the results from the program:

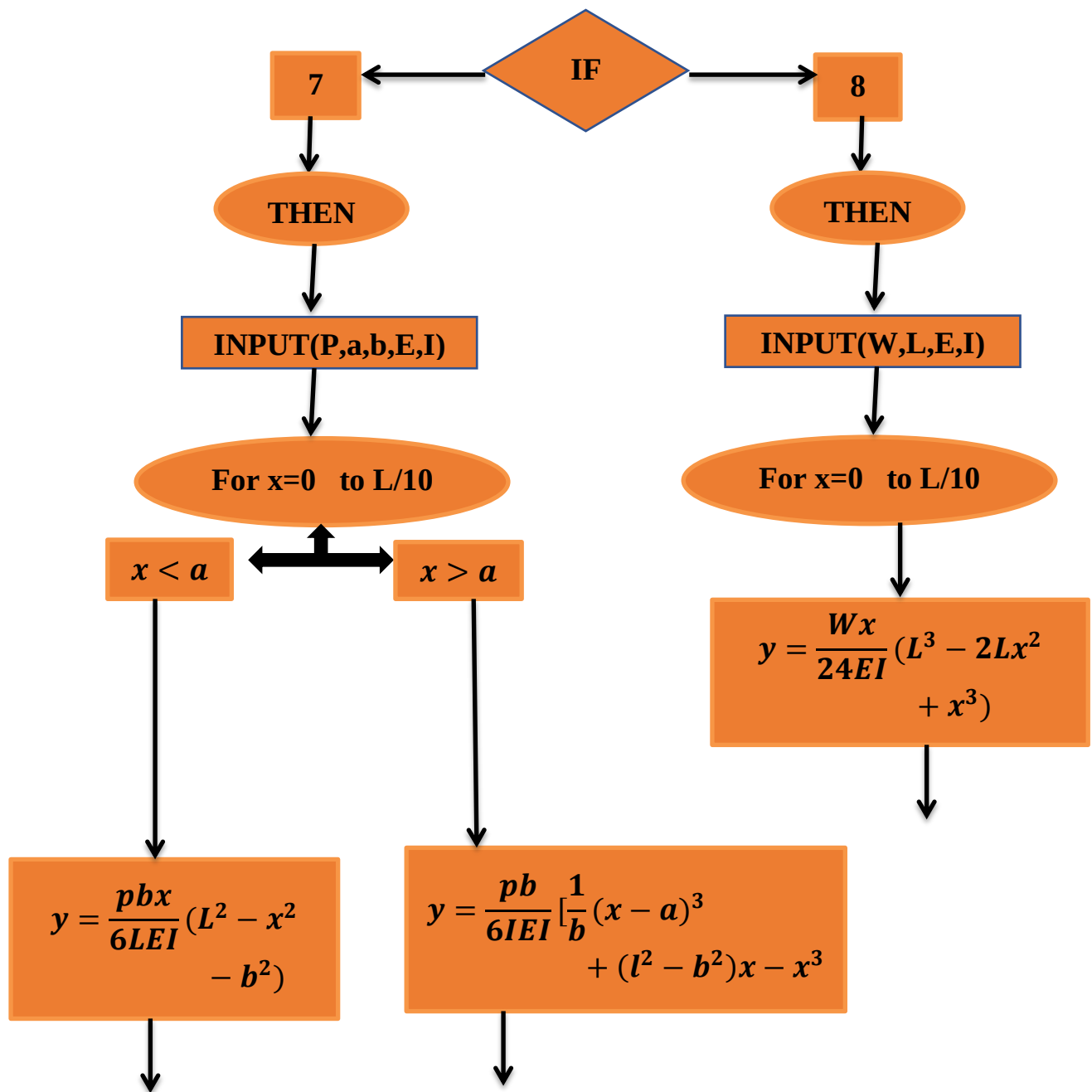
Program results	Results of the theory
1-Quickly extract results	1-Slow extraction results
2-Easy to explain to the user	2-It is used only by professionals in this field
3-It gives precision to the outputs several times and as we noticed in one example of distortion, we used it for different distances	3-The accuracy of the results in the equations is not as large as it is specific as in the examples of deformation where we used the equation for a certain distance and not for many distances
4- he program can be programmed to calculate all cases, for example, related to deformation, and therefore upon implementation, we can obtain results with a lower voltage and a great speed	4-he equations are different for each case, and therefore require a long time to find the deformation for each case, this means high and slow effort to extract the results.

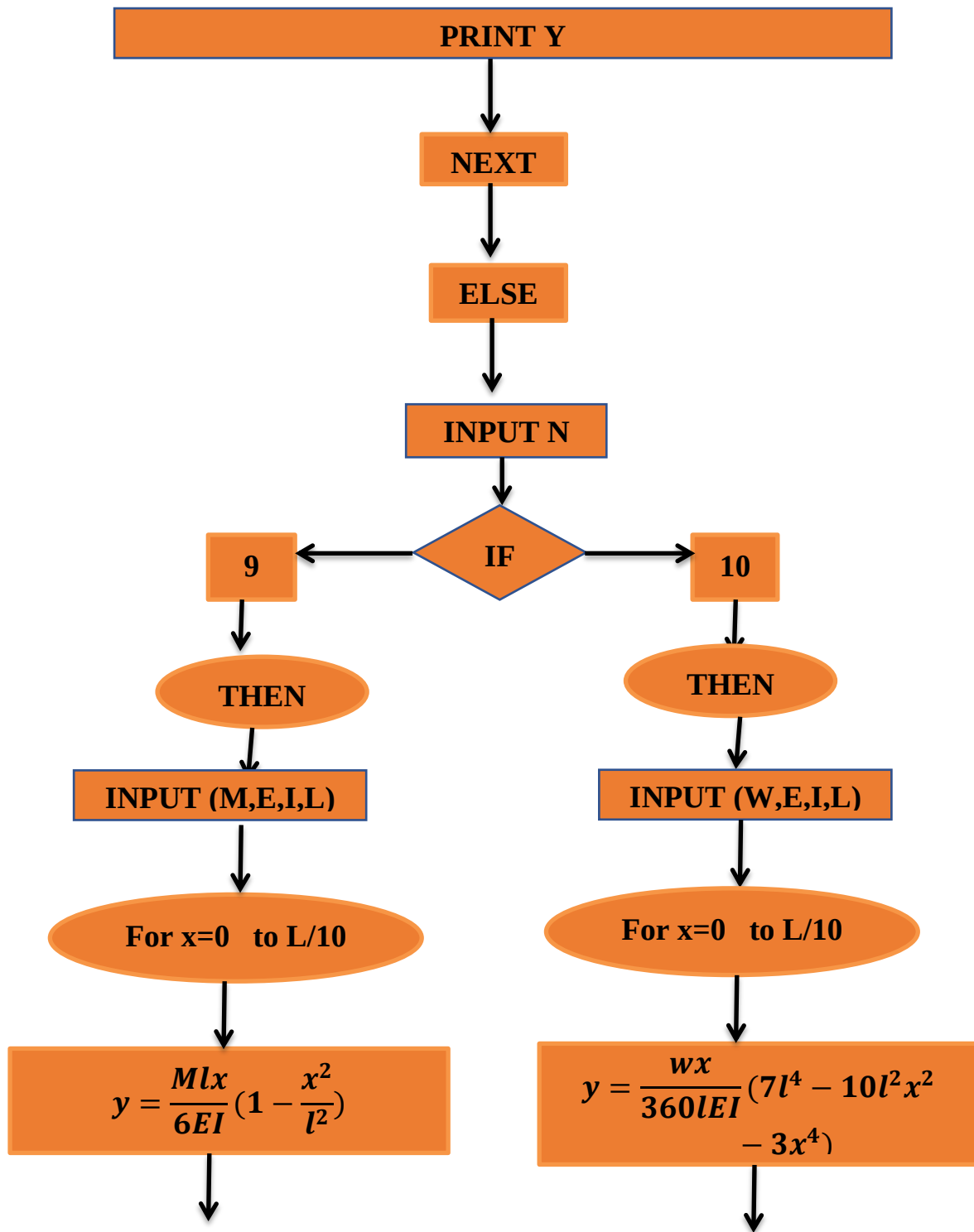
3.9 program and flowchart:

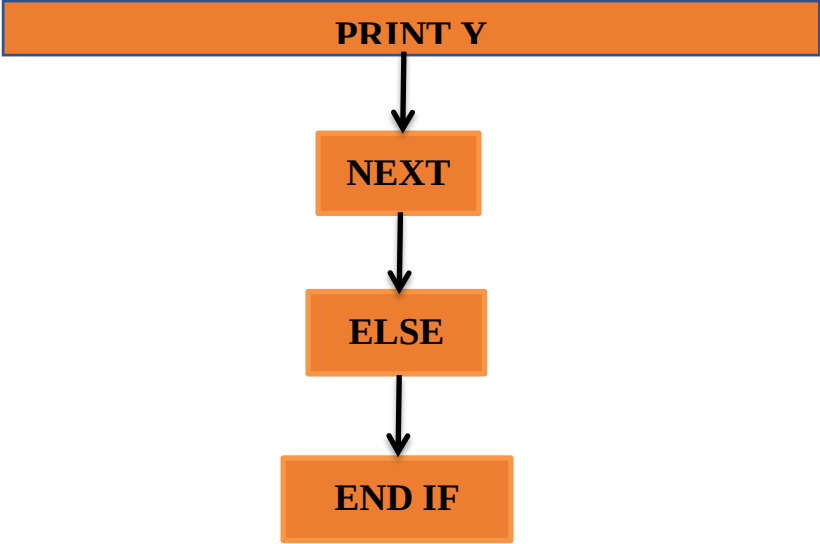












4

CHAPTER FOUR

Conclusions & Further Works

Conclusions & Further Works

4.1 Conclusion:

Using the Q basic program, it became easy for us to extract the results and calculations for the various engineering equations that we need in our work, including the deformation equations in beams, many different equations that need to be manually resolved with great effort and time as well, but through the program it became easy to solve and not only One equation, but all possible equations through easy programming possible for the user when I read it to understand and use it in a very simple way where once you input the input to the program is entered we will get the results with high accuracy and speed.

4.2 Further Work:

- 1-The program can be made to perform calculations other than deformation in beams, such as calculating moments, as well as the procedure that occurs in beams, by making adjustments to the program likewise.
- 2-It is possible to make a single program that calculates both the deformation in the thresholds as well as the calculation of moments and stress in one program by performing some appropriate operations for our program.

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2. SINGER, F 1980 ., Strength of materials. Harper international edition, third edition 1998.
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Republic of Iraq
Ministry of Higher Education and Scientific Research
Al-Mustansiriyah University
College of Engineering
Civil Engineering Department

**A Visual Basic .6 Program to Draw the Bending Moment
and Shear Force Daigrams for Simply Supported Beam
Depending on Finite Difference Method**

**A Project Submitted To The Civil Engineering Department, College of Engineering, Al-Mustansiriyah
University In a Partial Fulfillment of The Requirements for The Degree of Bachelor's In Civil Engineering.**

By:

Zahraa Zamil Salih

Supervised By:

Asst. Lect. Essam H. Elaiwi

2019-2020

DEDICATION

To my parents and to my family who made this accomplishment possible.

ACKNOWLEDGMENTS

First and foremost, I would like to thank all my teachers from primary school to this our day.

I would like to thank my family, especially my parents, for their encouragement, Patience, and assistance over the years.

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ABSTRACT

The programs are important for the job market and are the main reason for qualification for any job and the reason for that development and speed of modernity and because it took a long time in the calculations, therefore, a program was written in "*Visual Basic 6*" to calculate deflection, slope, shear force and bending moment depending on "*finite difference method*" and using "*Gauss elimination Method*" to solve the set of equations.

As the project is limited to statically determinate of beams and simply supported, by inserting the modulus of elasticity for each material, whether concrete or steel, and inserting the moment of inertia depending on the cross section. It is important to use a number of elements for the length of beam, where the more the number of elements give better results in more accurate of calculations.

The loads are three types "*concentrated load, distributed load and trapezoid load including the triangle*", away far from the external bending moment and torque, wind load and earthquake.

Chapter One

INTRODUCTION

Chapter One

1.INTRODUCTION

In the past it was common practice to teach structural analysis and stress analysis, or theory of structures and strength of materials as they were frequently known, as two separate subjects where., generally, structural analysis was concerned with the calculation of internal force systems and stress analysis involved the determination of the corresponding internal stresses and associated strains. Inevitably a degree of overlap occurred. For example, the calculation of shear force and bending moment distributions in beams would be presented in both structural and stress analysis courses, as would the determination of displacements. In fact, a knowledge of methods of determining displacements is essential in the analysis of some statically indeterminate structures. Clearly, therefore, it is logical to present a unified approach in which the ‘story’ can be told progressively with one topic following naturally on from another. Initially we shall examine the functions and forms of structures together with support systems and the difference between statically determinate and statically indeterminate structures. It can be noted to the program used in this project, which have been designed and implemented of a Computerized System for Numerical Methods Simulation (CSNMS) as teaching tool furnishes a background necessary for studying numerical analysis (numerical methods) theory. This program is a simple application tool, which provides an interactive and simplified interface for students. The system consists of different techniques with different algorithms has been implemented to provide wider choice for the students in order to make it easier for them to understand the fundamentals of numerical methods. The simulation results from the testing of the system demonstrated that the system works correctly and meant all constraints. With the development of speed and efficient digital computers, the role of numerical methods in solving scientific and engineering problems has been increasing at rapid pace in recent years. Currently, Introduction to numerical methods course for engineering students at the undergraduate level as a general and fundamental tool for all engineering disciplines. Computer programming languages will be essential, some are compulsory some are elective and there are some that don’t need to be given in some departments or are not needed for later purposes; many today’s popular commercial software packages widely used in science and engineering such as Matlab [Mathworks Inc.2012],

Maple, Mathcad and Mathematica [Castillo, et al., 1994]. Beside programming languages such as Fortran, Basic, Pascal, C, C++, and Microsoft Excel/VBA [Deitel, 1999; Walkenbach, 2004]. These resources often termed as “teaching tools” in academic environment. Most of previous researches were using packages or programming languages as mentioned above such as [Conte, 1965; Haggerty, 1972; Aslan et al.,

2002; Hassan, et al., 2006; Wlodkowski, 2006] for solving problems. Conte (1965), uses of Fortran IV programming language they make a comparison between analytical and programming method of solving numerical and came up with a conclusion that programming method of solving numerical iterations using computer is faster than using analytical method and save time with a very negligible errors or no errors incurred at all. Haggerty G.B(1972), He also used FORTRAN IV programming languages for the algorithms. (Yüncü, Aslan, 2002), C++ was used in numerical analysis learning as a developed visual package program. (Hassan, etc., 2006), for the execution of numerical iterations. Above all, these researchers make uses of FORTRAN IV programming language which is a text based language. Text based language do not allow the users to work directly with graphics and this is one disadvantages why the use of FORTRAN IV programming language is not consider for use in this research work, rather visual basic programming language is consider for use. In addition, the recent work with visual basic to implemented the application for the limited iteration solution. But our software system aims to provide both simple and user-friendly tool for students to investigate numerical methods basic concepts that allow students with less programming knowledge and skill and the ability to select the appropriate numerical method to be used with the particular problem under consideration.

1.1 Structural Form

The decision as to the form of a structure rests with the structural designer and is governed by the purpose for which the structure is required, the materials that are to be used and any aesthetic considerations that may apply. At the same time a designer may face a situation in which more than one structural form will satisfy the requirements of the problem so that the designer must then rely on skill and experience to select the best solution. On the

other hand there may be scope for a new and novel structure which provides savings in cost and improvements in appearance. Structures, for construction and analysis purposes, are divided into a number of structural elements, although an element of one structure may, in another situation, form a complete structure in its own right. As spans increase, the use of beams to support bridge decks becomes uneconomical.

1.2 Support Systems

The loads applied to a structure are transferred to its foundations by its supports. In practice supports may be complex, in which case they are idealized into a form that may readily be analysed. Thus a support that allows rotation but prevents translation in practice. A beam that is supported at one end by a pinned support would not necessarily be supported in the same way at the other. One support of this type is sufficient to maintain the horizontal equilibrium of a beam and it may be advantageous to allow horizontal

movement of the other end so that, for example, expansion and contraction caused by temperature variations do not induce additional stresses. Such a support may take the form of a composite steel and rubber bearing as shown in Fig. 1.1(a) or consist of a roller sandwiched between steel plates. In an idealized form, this type of support is represented as shown in Fig. 1. 1 (b) and is called a roller support. it is assumed that such a support allows horizontal movement and rotation but prevents movement vertically, up or down. When loads are applied to a structure, reactions are generated in the supports and in many structural analysis problems the first step is to calculate their values. It is important, therefore, to identify correctly the type of reaction associated with a particular support. Thus, supports that prevent translation in a particular direction produce a force reaction in that direction while supports that prevent rotation induce moment reactions.

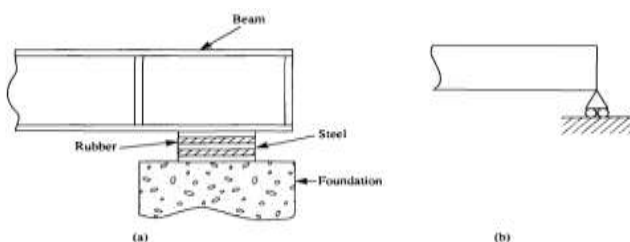


Fig. 1.1 Idealization of a sliding or roller support

1.3 Statically determinate and indeterminate structures

In many structural systems the principles of statical equilibrium, may be used to determine support reactions and internal force distributions; such systems are called statically determinate. Systems for which the principles of statical equilibrium are insufficient to determine support reactions and/or internal force distributions, i.e. there are a greater number of unknowns than the number of equations of statical equilibrium, are known as statically indeterminate or hyperstatic systems. However, it is possible that even though the support reactions are statically determinate, the internal forces are not, and vice versa.

Chapter Two

PRINCIPLES OF STATICS

2.PRINCIPLES OF STATICS

Statics, as the name implies, is concerned with the study of bodies at rest or, in other words, in equilibrium, under the action of a force system. Actually, a moving body is in equilibrium if the forces acting on it are producing neither acceleration nor deceleration. However, in structural analysis, structural members are generally at rest and therefore in a state of statical equilibrium.

2.1 Force

The definition of a force is derived from Newton's First Law of Motion which states that a body will remain in its state of rest or in its state of uniform motion in a straight line unless compelled by an external force to change that state. Force is therefore associated with a change in motion, i.e. it causes acceleration or deceleration. We all have direct experience of force systems. The force of the earth's gravitational pull acts vertically downwards on our bodies giving us weight; wind forces, which can vary in magnitude, tend to push us horizontally. Forces therefore possess magnitude and direction. At the same time the effect of a force depends upon its position. For example, a door may be opened or closed by pushing horizontally at its free edge, but if the same force is applied at any point on the vertical line through its hinges the door will neither open nor close. Thus we see that a force is specified by its magnitude, direction and position and is therefore a vector quantity. As such it must obey the laws of vector addition, which is a fundamental concept that may be verified experimentally.

Since a force is a vector it may be represented graphically as shown in Fig. 2.1, where the force F is considered to be acting on an infinitesimally small particle at the point A and in a direction from left to right. The magnitude of F is represented, to a suitable scale, by the length of the line AB and its direction by the direction of the arrow. In vector notation the force F is written as $\vec{F}$. Consider now a cube of material placed on a horizontal surface and acted upon by a force F , as shown in Fig. 2.2(a). If F , is greater than the frictional force

between the surface and the cube, the cube will move in the direction of F_1 . Similarly if a force F_2 is applied as shown in Fig. 2.2(b) the cube will move in the direction of F_2 .

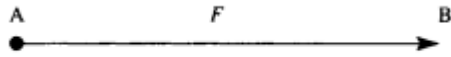


Fig. 2.1 Representation of a force by a vector

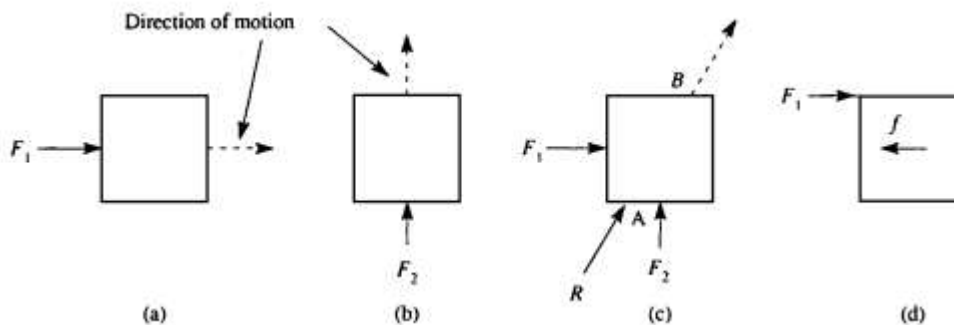


Fig. 2.2 Action of forces on a cube

It follows that if F_1 and F_2 were applied simultaneously, the cube would move in some inclined direction as though it were acted on by a single inclined force R (Fig. 2.2(c)); clearly R is the resultant of F_1 and F_2 . Note that F_1 and F_2 (and R) are in a horizontal plane and that their lines of action pass through the centre of gravity of the cube, otherwise rotation as well as translation would occur since, if F_2 , say, were applied at one corner of the cube as shown in Fig. 2.2(d), the frictional force f , which would act at the centre of the bottom face of the cube would, with F_1 , form a couple (see Section 2.2). The effect of the force R on the cube would be the same whether it was applied at the point A or at the point B (so long as the cube is rigid). Thus a force may be considered to be applied at any point on its line of action, a principle known as the transmissibility of a force.

Parallelogram of forces

The resultant of two concurrent and coplanar forces, whose lines of action pass through a single point and lie in the same plane (Fig. 2.3(a)), may be found using the theorem of the parallelogram of forces which states that: *If two forces acting at a point are represented by two adjacent sides of a parallelogram drawn from that point their resultant is represented in magnitude and direction by the diagonal of the parallelogram drawn through the point.* Thus in Fig. 2.3(b) R is the resultant of F_1 and F_2 . This result may be verified experimentally or, alternatively, demonstrated to be true using the laws of vector addition. Thus in Fig. 2.3(b) the side BC of the parallelogram is equal in magnitude and direction to the force F_1 , represented by the side OA . Therefore, in vector notation

$$R = F_2 + F_1$$

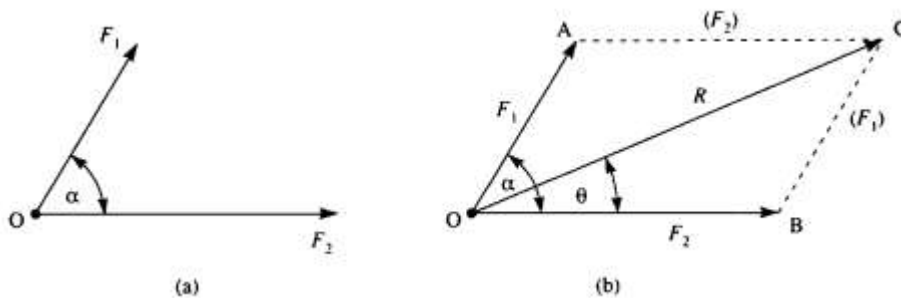


Fig. 2.3 Resultant of two concurrent forces

The same result would be obtained by considering the side AC of the parallelogram which is equal in magnitude and direction to the force F_2 . Thus

$$R = F_1 + F_2$$

Note that vectors obey the commutative law, i.e.

$$F_2 + F_1 = F_1 + F_2$$

The determination of the actual magnitude and direction of R may be carried out graphically by drawing the vectors representing F_1 and F_2 to the same scale (i.e. OB and BC)

and then completing the triangle OBC by drawing in the vector, along OC, representing R. Alternatively R and θ may be calculated using the trigonometry of triangles. Hence

$$R^2 = F_1^2 + F_2^2 + 2 F_1 F_2 \cos \alpha \quad (2.1)$$

$$\tan \theta = \frac{F_1 \sin \alpha}{F_2 + F_1 \cos \alpha} \quad (2.2)$$

In Fig. 2.3(a) both F_1 and F_2 are ‘pulling away’ from the particle at O. In Fig. 2.4(a) F_1 is a ‘thrust’ whereas F_2 remains a ‘pull’. To use the parallelogram of forces the system must be reduced to either two ‘pulls’ as shown in Fig. 2.4(b) or two ‘thrusts’ as shown in Fig. 2.4(c). In all three systems we see that the effect on the particle at O is the same. As we have seen, the combined effect of the two forces F_1 and F_2 , acting simultaneously is the same as if they had been replaced by the single force R. Conversely, if R were to be replaced by F_1 and F_2 , the effect would again be the same. F_1 and F_2 may therefore be regarded as the components of R in the directions OA and OB; R is then said to have been resolved into two components, F_1 and F_2 . Of particular interest in structural analysis is the resolution of a force into two components at right angles to each other. In this case the parallelogram of Fig. 2.3(b) becomes a rectangle in which $\alpha = 90^\circ$ (Fig. 2.5) and, clearly,

$$F_2 = R \cos \theta, \quad F_1 = R \sin \theta \quad (2.3)$$

It follows from Fig. 2.5, or from Eqs (2.1) and (2.2), that

$$R^2 = F_1^2 + F_2^2, \quad \tan \theta = F_1 / F_2 \quad (2.4)$$

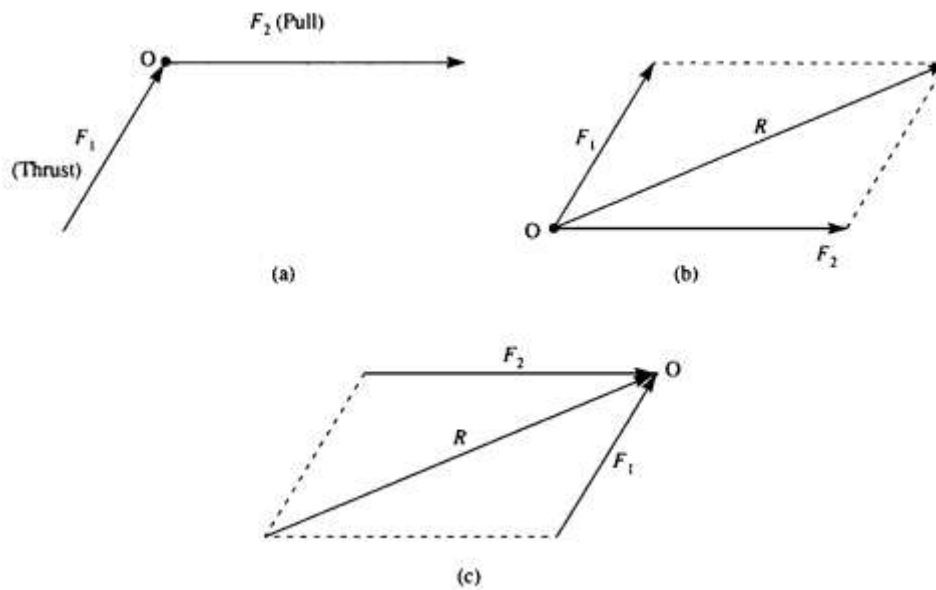


Fig. 2.4 Reduction of a force system

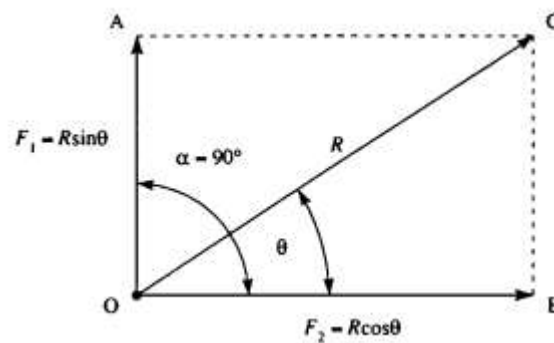


Fig. 2.5 Resolution of a force into two components at right angles

We note, by reference to Figs 2.2(a) and (b), that a force does not induce motion in a direction perpendicular to its line of action; in other words a force has no effect in a direction perpendicular to itself. This may also be seen by setting $\theta = 90^\circ$ in Eqs (2.3), then

$$F_1 = R, \quad F_2 = 0$$

and the component of R in a direction perpendicular to its line of action is zero.

2.2 Moment of a force

The moment of a force, F , about a given point O , as the product of the force and the perpendicular distance of its line of action from the point. In Fig. 2.6(a) the bar AB is attached to a hinge which allows it to rotate in a horizontal plane (Fig. 2.6 (a) is a plan view). A force F whose line of action passes through the hinge will have no rotational effect on the bar but, when acting at some point along the bar as in Fig. 2.6 (b), will cause the bar to rotate about the hinge. Further, it is common experience that the greater the distance of F from the hinge, the greater will be its effect. (Thus a greater force is required to close a door when the force is applied near to the vertical line through its hinges than if the force were applied close to the free edge, the usual position for a door knob or handle.) At the same time, the force F exerts its greatest effect when it acts at right angles to the bar. If it were inclined, as shown in Fig. 2.6(c), such that its line of action passed through the hinge it would exert no rotational effect on the bar at all. In Fig. 2.6 (b) F is said to exert a moment on the bar about the hinge, which is usually referred to as the fulcrum. Clearly the rotational effect of F depends upon its magnitude and also on its distance from the hinge. We therefore define the moment of a force, F , about a given point O (Fig. 2.7) as the product of the force and the perpendicular distance of its line of action from the point. Thus, in Fig. 2.7, the moment, M , of F about O is given by

$$M = F a \quad (2.5)$$

where 'a' is known as the lever arm or moment arm of F about O ; note that the units of a moment are the units of force x distance

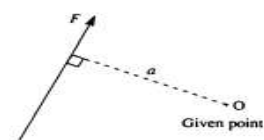
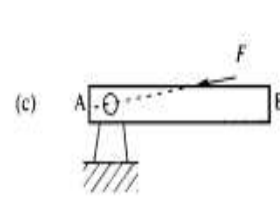
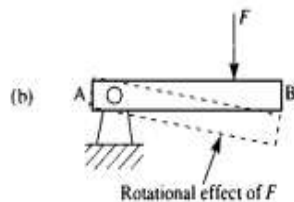
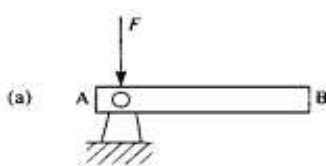


Fig. 2.6 Rotational effect of a force

Fig. 2.7 Moment of a force about a given point

It can be seen from the above that a moment possesses both magnitude and a rotational sense; in Fig. 2.7, for example, F exerts a clockwise moment about O . A moment is therefore a vector (an alternative argument is that the product of a vector, F , and a scalar, Q , is a vector). It is conventional to represent a moment vector graphically by a double-headed arrow, where the direction of the arrow designates a clockwise moment when looking in the direction of the arrow. Therefore, in Fig. 2.7, the moment $M(=Fa)$ would be represented by a double headed arrow through O with its direction into the plane of the paper. Moments, being vectors, may be resolved into components in the same way as forces. Consider the moment,

M , (Fig. 2.8(a)) in a plane inclined at an angle θ to the xz plane. The component of M in the xz plane, M_{xz} may be imagined to be produced by rotating the plane containing M through the angle θ into the xz plane. Similarly, the component of M in the yz plane, M_{yz} is obtained by rotating the plane containing M through the angle $90^\circ - \theta$. Vectorially, the situation is that shown in Fig. 2.8(b), where the directions of the arrows represent clockwise moments when viewed in the directions of the arrows. Then

$$M_{xz} = M \cos \theta, \quad M_{yz} = M \sin \theta$$

The action of a moment on a structural member depends upon the plane in which it acts. In Fig. 2.9(a), for example, the moment, M , which is applied in the

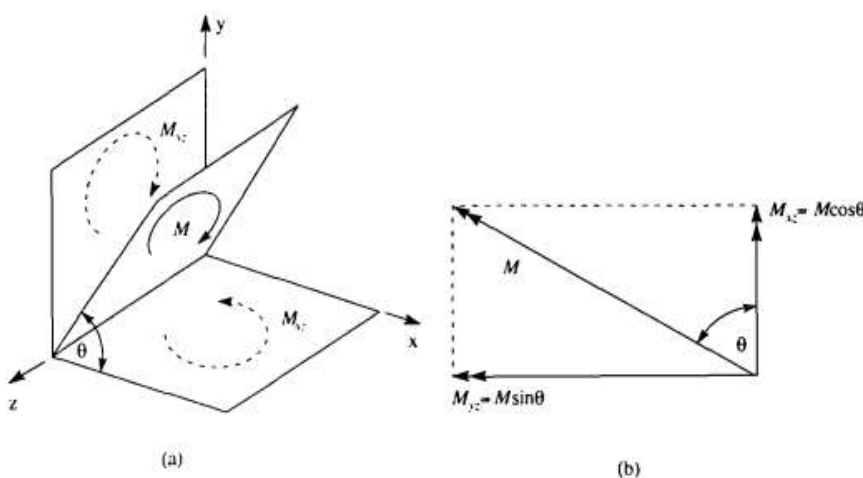


Fig. 2.8 Resolution of a moment

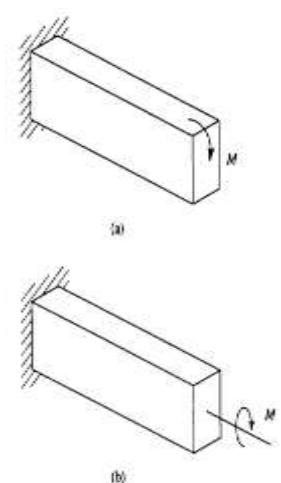


Fig. 2.9 Action of a moment in different planes

longitudinal vertical plane of symmetry, will cause the beam to bend in a vertical plane. In Fig. 2.9(b) the moment, M , is applied in the plane of the cross-section of the beam and will therefore produce twisting; in this case M is called a torque.

2.3 The resultant of a system of parallel forces

A system of forces may be replaced by their resultant, it follows that a particular action of a force system, say the combined moments of the forces about a point, must be identical to the same action of their resultant. This principle may be used to determine the magnitude and line of action of a system of parallel forces such as that shown in Fig. 2.10(a). The point of intersection of the lines of action of F_1 and F_2 is at infinity so that the parallelogram of forces (Fig. 2.3(b)) degenerates into a straight line as shown in Fig. 2.10(b) where, clearly

$$R = F_1 + F_2 \quad (2.6)$$

The position of the line of action of R may be found using the principle stated above, i.e. the sum of the moments of F_1 and F_2 about any point must be equivalent to the moment of R about the same point. Thus from Fig. 2.10(a) and taking moments about, say, the line of action of F_1 , we have

$$F_2 a = R x = (F_1 + F_2) x$$

$$X = F_2 a / F_1 + F_2 \quad (2.7)$$

Note that the action of R is equivalent to that of F_1 and F_2 , so that, in this case, we equate clockwise to clockwise moments. The principle of equivalence may be extended to any number of parallel forces irrespective of their directions and is of particular use in the calculation of the position of centroids of area.

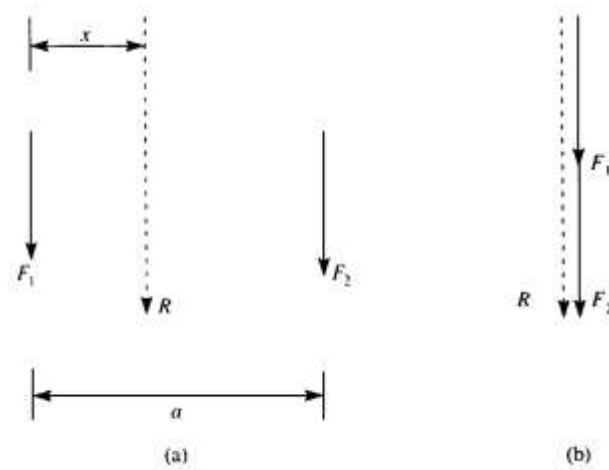


Fig. 2.10 Resultant of a system of parallel forces

2.4 Equilibrium of force systems

The resultant force on the particle or body must be zero. Thus, if a body (generally in structural analysis we are concerned with bodies, i.e. structural members, not particles) is not to move in a particular direction, the resultant force in that direction must be zero. Furthermore, the prevention of the movement of a body in two directions at right angles ensures that the body will not move in any direction. It follows that, for such a body to be in equilibrium, the sum of the components of all the forces acting on the body in any two mutually perpendicular directions must be zero. In mathematical terms and choosing, say, the x and y directions as the mutually perpendicular directions, the condition may be written

$$\sum Fx = 0, \quad \sum Fy = 0 \quad (2.8)$$

However, the condition specified by Eqs (2.8) is not sufficient to guarantee the equilibrium of a body acted on by a system of coplanar forces. In Fig. 2.11, for example, the forces F acting on a plate resting on a horizontal surface satisfy the condition $\sum Fx = 0$ (there are no forces in the y direction so that $\sum Fy = 0$ is automatically satisfied), but form a couple Fa which will cause the plate to rotate in an anticlockwise sense so long as its magnitude is sufficient to overcome the frictional resistance between the plate and the surface. We have also seen that a couple exerts the same moment about any point in its plane so that we may deduce a further condition for the statical equilibrium of a body acted upon by a system of

coplanar forces, namely, that the sum of the moments of all the forces acting on the body about any point in their plane must be zero. Therefore, designating a moment in the xy plane about the z axis as M_z , we have

$$\sum M_z = 0 \quad (2.9)$$

Combining Eqs (2.8) and (2.9) we obtain the necessary conditions for a system of coplanar forces to be in equilibrium. Thus

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum M_z = 0 \quad (2.10)$$

The above arguments may be extended to a three-dimensional force system which is, again, referred to an xyz axis system. Thus for equilibrium

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum F_z = 0 \quad (2.11)$$

$$\sum M_x = 0, \quad \sum M_y = 0, \quad \sum M_z = 0 \quad (2.12)$$

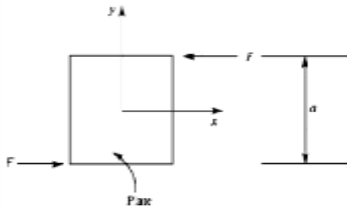


Fig. 2.11 Couple produced by out-of-line forces

2.5 Normal Force, Shear Force and Bending Moment

A knowledge of stress is essential in structural design where the cross-sectional area of a member must be such that stresses do not exceed values that would cause breakdown in the crystalline structure of the material of the member; in other words, a structural failure. In addition to stresses, strains, and thereby displacements, must be calculated to ensure that as well as strength a structural member possesses sufficient stiffness to prevent excessive distortions damaging surrounding portions of a complete structure.

2.5.1 Types of loads

Structural members may be subjected to complex loading systems apparently comprised of several different types of load. However, no matter how complex such systems appear to be they consist of a maximum of four basic load types: axial loads, shear loads, bending moments and torsion.

Axial load

Axial loads are applied along the longitudinal or centroidal axis of a structural member. If the action of the load is to increase the length of the member, the member is said to be in tension (Fig. 2.12 (a)) and the applied load is tensile. A load that tends to shorten a member places the member in compression and is known as a compressive load (Fig. 2.12 (b)). Members such as those shown in Figs 2.12 (a) and (b) are commonly found in pin-jointed frameworks where a member in tension is called a tie and one in compression a strut or column. More frequently, however, the name 'column' is associated with a vertical member carrying a compressive load, as illustrated in Fig. 2.12 (c).

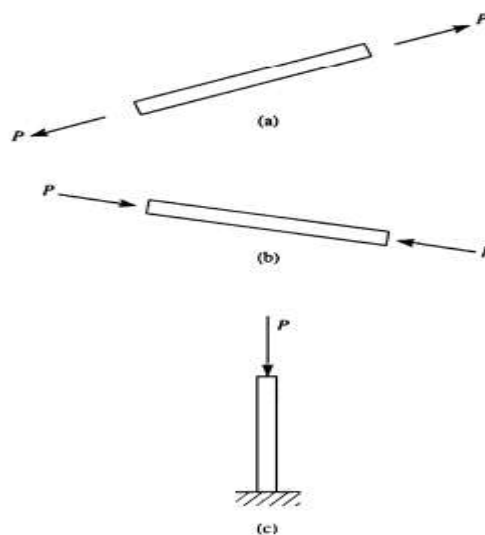


Fig. 2.12 Axially loaded members

Shear load

Shear loads act perpendicularly to the axis of a structural member and have one of the forms shown in Fig. 2.13; in this case the members are beams. Fig. 2.13(a) shows a concentrated shear load, W , applied to a cantilever beam. The shear load in Fig. 2.13(b) is distributed over a length of the beam and is of intensity w (force units) per unit length.

Bending moment

In practice it is difficult to apply a pure bending moment such as that shown in Fig. 2.14(a) to a beam. Generally, pure bending moments arise through the application of other types of load to adjacent structural members. For example, in Fig. 2.14(b), a vertical member BC is attached to the cantilever AB and carries a horizontal shear load, P (as far as BC is concerned). AB is therefore subjected to a pure moment, $M = Ph$, at B together with an axial load, P .

Torsion

A similar situation arises in the application of a pure torque, T (Fig. 2.15(a)), to a beam. A practical example of a torque applied to a cantilever beam is given in Fig. 2.15(b) where the horizontal member BC supports a vertical shear load at C. The cantilever AB is then subjected to a pure torque, $T = Wh$, plus a shear load, W .

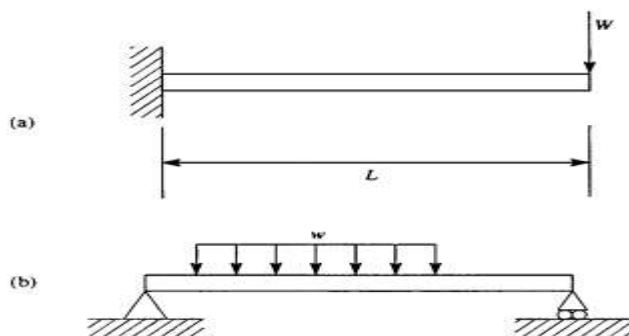


Fig. 2.13 Shear loads applied to beams

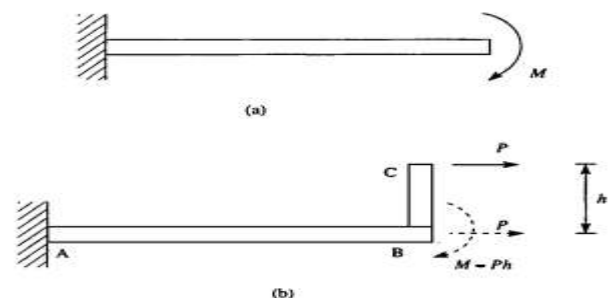


Fig. 2.14 Moments applied to beams

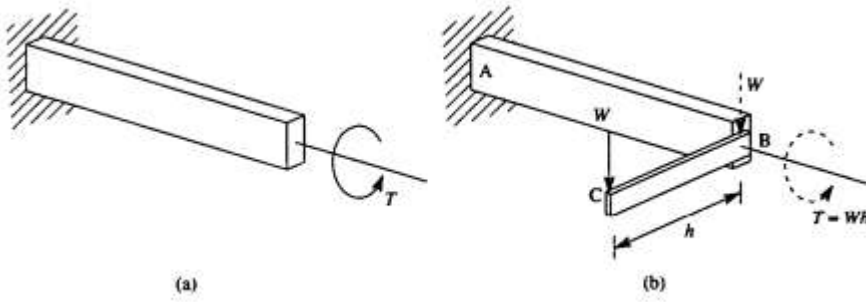


Fig. 2.15 Torques applied to a beam

2.5.2 Normal force

Example 2.1 Construct a normal force diagram for the beam AB shown in Fig. 2.16(a), since the beam is on a roller support at B, the horizontal load at B is reacted at A; clearly $R_{A,H} = 10$ kN acting to the left. Generally the distribution of an internal force will change at a loading discontinuity. In this case there is no loading discontinuity at any section of the beam so that we can determine the complete distribution of the normal force by calculating the normal force at any section Z, a distance : from A. Consider the length AZ of the beam as shown in Fig. 2.16(b) (equally we could consider the length ZB). The internal normal force acting at Z is N_{AB} which is shown acting in a positive (tensile) direction. The length AZ of the beam is in equilibrium under the action of $R_{A,H}$ ($= 10$ kN) and N_{AB} .

$$N_{AB} - R_{A,H} = N_{AB} - 10 = 0$$

whence

$$N_{AB} = 10 \text{ KN}$$

N_{AB} is positive and therefore acts in the assumed positive direction; the normal force diagram for the complete beam is then as shown in Fig. 2.16(c).

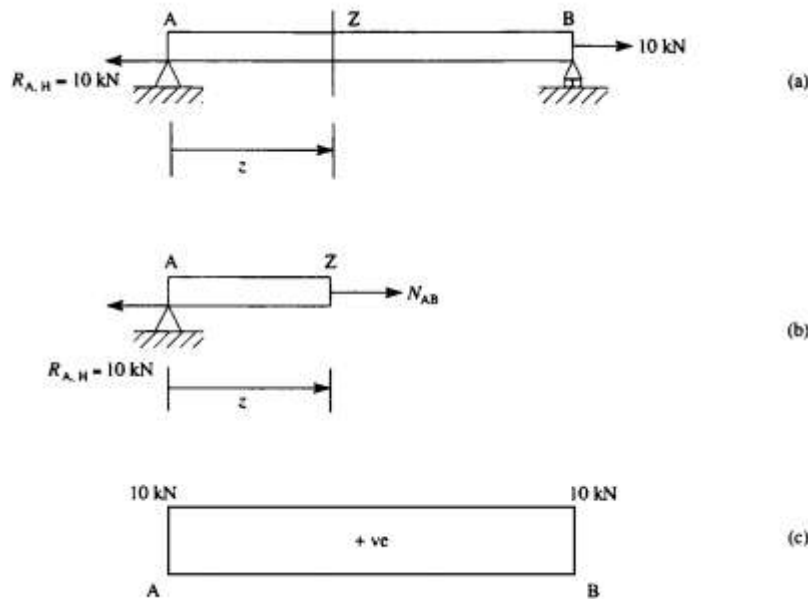


Fig. 2.16 Normal force diagram for the beam of Ex. 2.1

When the equilibrium of a portion of a structure is considered as in Fig. 2.19(b) we are using what is termed a *free body diagram*

2.5.3 Shear force and bending moment

It is convenient to consider shear force and bending moment distributions in beams simultaneously since they are directly related. Again the method of construction of shear force and bending moment diagrams will be illustrated by examples

Example 2.2 In this example it is necessary to calculate the value of the support reactions, both of which are seen, from symmetry, to be $W/2$ (Fig. 2.17(a)). Also, there is a loading discontinuity at B, so that we must consider the shear force and bending moment first at an arbitrary section Z, say, between A and B and then at an arbitrary section Zz between B and C. From the free body diagram in Fig. 2.17(b) in which both S_{AB} and M_{AB} are in positive directions we see, by considering the vertical equilibrium of the length AZ, of the beam, that

$$S_{AB} - W/2 = 0$$

whence

$$S_{AB} = + W/2$$

S_{AB} is therefore constant at all sections of the beam between A and B, in other words, from a section immediately to the right of A to a section immediately to the left of B. Now consider the free body diagram of the length Z_2C of the beam in Fig. 2.17(c). Note that, equally, we could have considered the length ABZ_2 , but this would have been slightly more complicated in terms of the number of loads acting. For vertical equilibrium of Z_2C

$$S_{AB} + W/2 = 0$$

from which

$$S_{AB} = -W/2$$

and we see that S_{BC} is constant at all sections of the beam between B and C so that the complete shear force diagram has the form shown in Fig. 2.17(d). Note that the change in shear force from that at a section immediately to the left of B to that at a section immediately to the right of B is $-W$,

It would also appear from Fig. 2.17 (d) that there are two different values of shear force at the same section B of the beam. This results from the assumption that W is concentrated at a point which, practically, is impossible since there would then be an infinite bearing pressure on the surface of the beam. In practice, the load W and the support reactions would be distributed over a small length of beam (Fig. 2.18(a)) so that the actual shear force distribution would be that shown in Fig. 2.18(b). The distribution of the bending moment in AB is now found by considering the moment equilibrium about Z , of the length AZ , of the beam in Fig. 2.18(b). Thus

$$M_{AB} - Wz/2 = 0$$

or

$$M_{AB} = Wz/2 \quad (i)$$

Therefore M_{AB} varies linearly from zero at A ($z = 0$) to $+WL/4$ at B ($z = L/2$). Now considering the length Z_2C of the beam in Fig 2.17(c) and taking moments about Z_2

$$M_{BC} - W/2(L - z)$$

which gives

$$M_{BC} = W/2(L - z) \quad (ii)$$

From Eq. (ii) we see that M_{BC} varies linearly from $+ WL/4$ at B ($z = L/2$) to zero at C ($z = L$). The complete bending moment diagram is shown in Fig. 2.17(e). Note that the bending moment is positive (sagging) at all sections of the beam so that the lower surface of the beam is in tension. In this example the deflected shape of the beam would be that shown in Fig. 2.17(f).

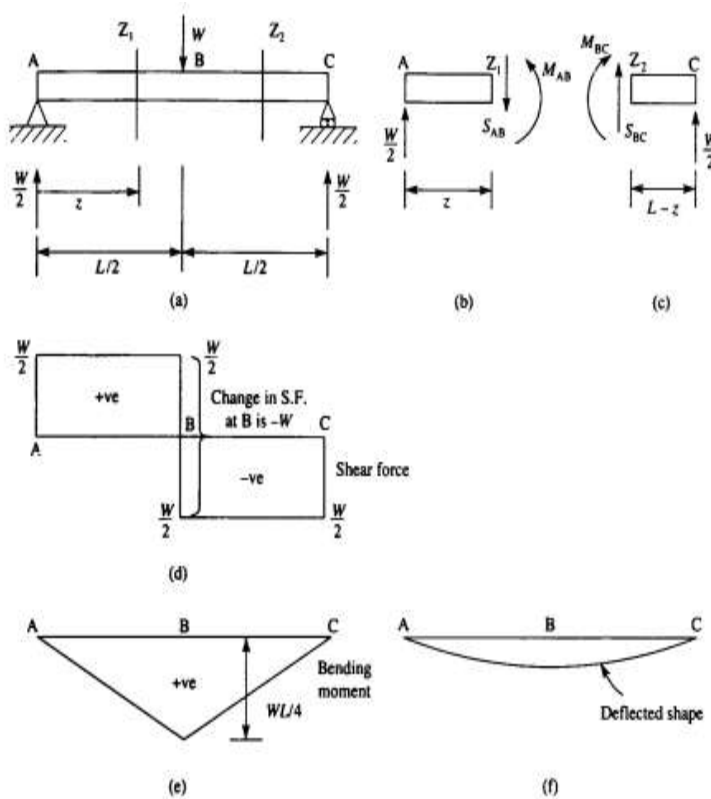


Fig.2.17 Shear force and bending moment diagrams for the beam of Ex 2.2

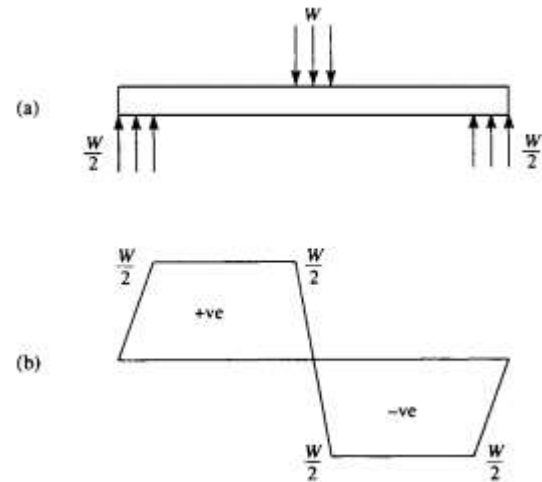


Fig. 2.18 Shear force diagram in a practical situation

Example 2.3 Simply supported beam carrying a uniformly distributed load.

The symmetry of the beam and its load may again be used to determine the support reactions which are each $wL/2$. Furthermore, there is no loading discontinuity between the ends A and B of the beam so that it is sufficient to consider the shear force and bending moment at just one section Z, a distance z , say, from A; again we draw in positive directions for the shear force and bending moment at the section Z in the free body diagram shown in Fig. 2.19 (b). Considering the vertical equilibrium of the length AZ of the beam gives

$$S_{AB} + W_2 - W(L/2) = 0$$

whence

$$S_{AB} = + W\left(\frac{L}{2} - z\right) \quad (i)$$

S_{AB} therefore varies linearly along the length of the beam from $+ wL/2$ at A ($z = 0$) to $- wL/2$ at B ($z = L$). Note that $S_{AB} = 0$ at mid-span ($z = L/2$).

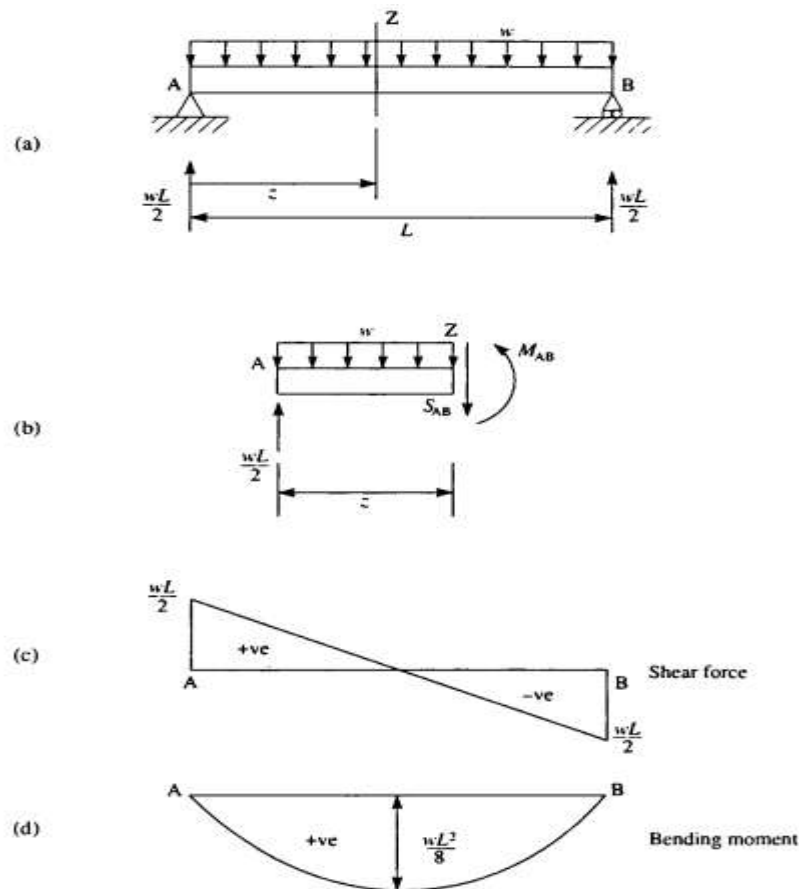


Fig. 2.19 Shear force and bending moment diagrams for the beam of Ex. 2.3

Now taking moments about Z for the length AZ of the beam in Fig. 2.19(b) we have

$$M_{AB} + Wz^2/2 - WLz/2 = 0$$

from which

$$M_{AB} = +Wz/2(L - z) \quad (ii)$$

Thus M_{AB} varies parabolically along the length of the beam and is positive (sagging) at all sections of the beam except at the supports ($z = 0$ and $z = L$) where it is zero.

Also, differentiating Eq. (ii) with respect to z gives

$$\frac{dM}{dz} = w \left(\frac{L}{2} - z \right) \quad (iii)$$

From Eq. (iii) we see that $dM_{AB}/dz=0$ at mid-span where $z=L/2$, so that the bending moment diagram has a turning value or mathematical maximum at this section. In this case this mathematical maximum is the maximum value of the bending moment in the beam and is, from Eq. (ii), $+ wL^2/8$. The bending moment diagram for the beam is shown in Fig. 2.19(d) where it is again drawn on the tension side of the beam; the deflected shape of the beam will be identical in form to the bending moment diagram.

2.6 Load, shear force and bending moment relationships

shear force and bending moment are related. Thus, for example, uniformly distributed loads produce linearly varying shear forces and maximum values of bending moment coincide with zero shear force. Since a distributed load varies the shear load according to its magnitude it can be derived that the slope of the shear diagram is equal to the magnitude of the distributed load. If a point load is applied to a member, and a linearly varying shear magnitude as a result of a constant distributed load. Similarly it can be shown that the slope of the moment diagram at a given point is equal to the magnitude of the shear diagram at that distance. Also if the shear diagram is zero over a length of the member, the moment diagram will have a constant value over that length. By calculus it can be shown that a point load will lead to a linearly varying moment diagram, and a constant distributed load will lead to a quadratic moment diagram.

Chapter Three

Finite Difference Model For A Simply Supported Beam

3. Finite Difference Model For A Simply Supported Beam

Introduction

In numerical analysis, finite-difference methods (FDM) are discretizations used for solving differential equations by approximating them with difference equations that finite differences approximate the derivatives.

FDMs convert linear ordinary differential equations (ODE) into a system of equations that can be solved by matrix algebra techniques. The reduction of the differential equation to a system of algebraic equations makes the problem of finding the solution to a given ODE ideally suited to modern computers

The governing differential equation for the beam bending problem, for the beam of length L with flexural rigidity EI under loading function $w(x)$, is given as

$$EIy'''' = w(x) \dots\dots\dots 1$$

When

E = Modulus of Elasticity

I = Moment of Inertia

Let we divide the beam of length L into n equidistant parts of length L/n , with points ordinate expressed as

$$x_i = \frac{iL}{n}, i = 0, 1, \dots, n$$

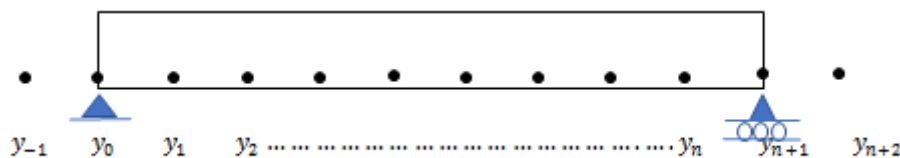


Figure. 3.1 Simply supported beam

The needed fourth derivative for beam bending problem is expressed at any point of the beam with

$$y''''(x) = \frac{y_{i-2} - 4y_{i-1} + 6y_i - 4y_{i+1} + y_{i+1}}{h^4}$$

So the stencil for the O.D.E will be

$$y_{i-2} - 4y_{i-1} + 6y_i - 4y_{i+1} + y_{i+2} = \frac{w(x)h^4}{EI} \dots\dots\dots 2$$

If we use FDM scheme for fourth derivative in y_1 or last points y_{n-1} of the beam, we have unknown function values for some points outside the beam as domain, (y_{-1} and y_{n+1}). With introducing the boundary conditions in FDM scheme we can avoid this unknown values outside the beam. With explicitly predefined boundary values (for simply supported beam), we are going to avoid values for y_{-1} and y_{n+1} . We do not need to take FDM scheme in that boundary points. For simply supported beam, moment is equal to zero. The expression for moment function at any point of the beam is given with

$$EIy''(x) = M(x)$$

$$EI \frac{(y_{i-1} - 2y_i + y_{i+1}))}{h^2} = M_i$$

At $x=0$ $M=0$

$$EI \frac{(y_{-1} - 2y_0 + y_1)}{h^2} = 0$$

$$\Rightarrow y_{-1} = -y_1$$

At $x=L$ $M=0$

$$EI \frac{(y_{i-1} - 2y_i + y_{i+1}))}{h^2} = M_i$$

$$EI \frac{(y_n - 2y_{n+1} + y_{n+2}))}{h^2} = 0$$

$$\Rightarrow y_{n+2} = -y_n$$

When the above stencil with the boundaries values is used in all unknown points, we will get the system of equations

$$k \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \\ y_8 \end{bmatrix} = \begin{bmatrix} \frac{w_1 h^4}{EI} \\ \frac{w_2 h^4}{EI} \\ \frac{w_3 h^4}{EI} \\ \frac{w_4 h^4}{EI} \\ \frac{w_5 h^4}{EI} \\ \frac{w_6 h^4}{EI} \\ \frac{w_7 h^4}{EI} \\ \frac{w_8 h^4}{EI} \end{bmatrix}$$

the k is the stiffness matrix and for the uniform and triangular distributed load is equal to

$$k = \begin{bmatrix} 5 & -4 & 1 & 0 & 0 & 0 & 0 & 0 \\ -4 & 6 & -4 & 1 & 0 & 0 & 0 & 0 \\ 1 & -4 & 6 & -4 & 1 & 0 & 0 & 0 \\ 0 & 1 & -4 & 6 & -4 & 1 & 0 & 0 \\ 0 & 0 & 1 & -4 & 6 & -4 & 1 & 0 \\ 0 & 0 & 0 & 1 & -4 & 6 & -4 & 1 \\ 0 & 0 & 0 & 0 & 1 & -4 & 6 & -4 \\ 0 & 0 & 0 & 0 & 0 & 1 & -4 & 5 \end{bmatrix}$$

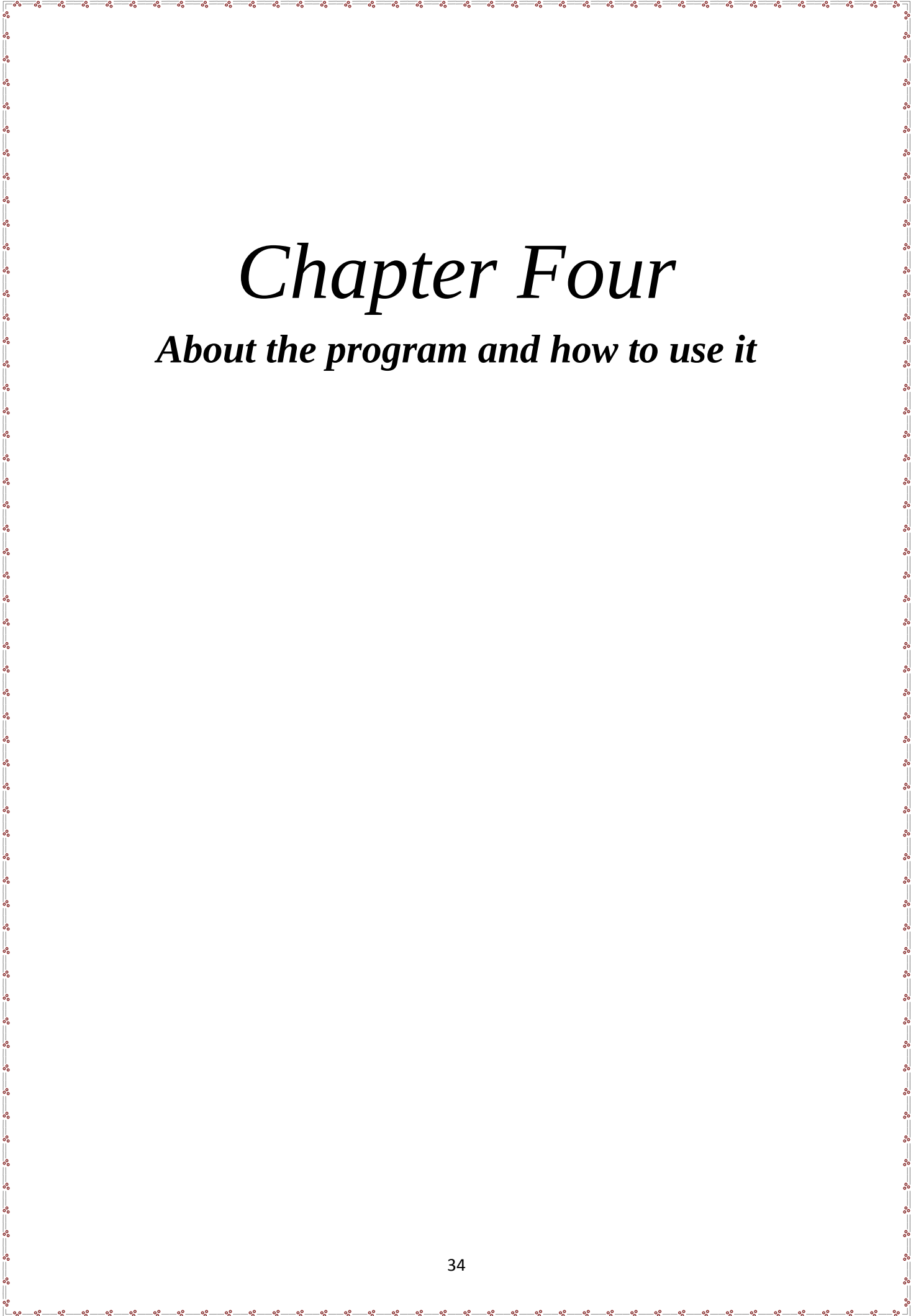
In same way we can get the stiffness matrix if the external load is concentrated load. In this case we should use the the third order differential equation or the second order as shown below.

$$EI y''' = V(x) \dots \dots \dots 3$$

$$EI \frac{-y_{i-2} + 2y_{i-1} + 0y_i - 2y_{i+1} + y_{i+2}}{2h^3} = V_i \dots \dots \dots 4$$

or $EI y'' = M(x) \dots \dots \dots 5$

$$EI \frac{(y_{i-1} - 2y_i + y_{i+1}))}{h^2} = M_i \dots \dots \dots 6$$



Chapter Four

About the program and how to use it

Visual Basic.6 Program and how to use it

Before starting using the computer program and its applications it is necessary to clarify some important points that must be followed by the user about how to use the program and how to enter the information to get the correct results. The program was prepared in a simple way away from complexity and in Arabic and used very simple methods so that people without specialty are able to use it and get accurate results without having the theoretical aspect of how to draw the shear force and bending moment diagrams.

How to Entering information

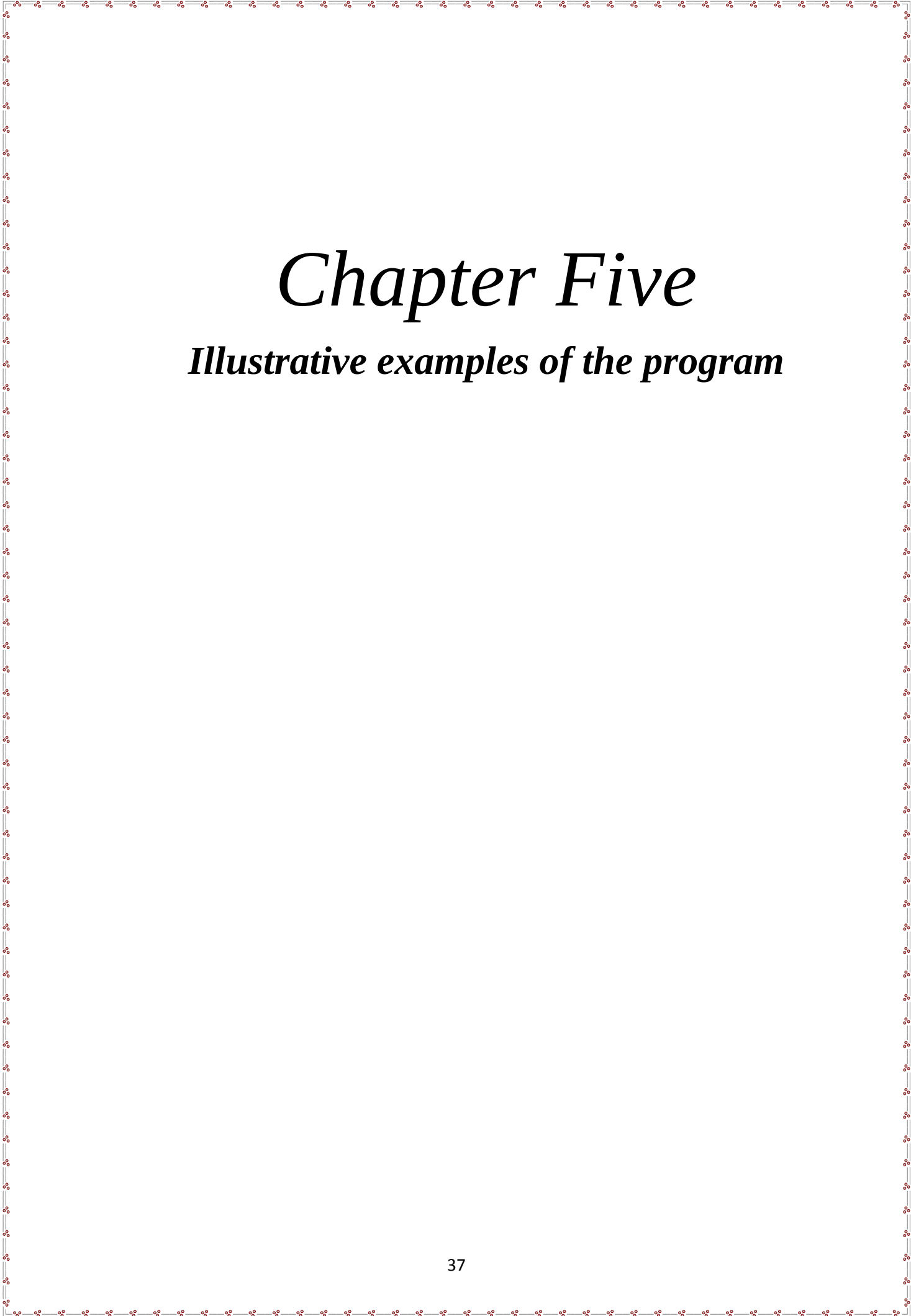
The way of entering data into any software in a computer is essential as proper data entry will inevitably result in reliable and correct results. Therefore, the important points in the entry about this program should be clarified as follow:

When you run the program, you'll see a list asking you to:

1. The beam length in meter
2. The number of concentrated loads
3. The number of uniform distributed loads
4. The number of trapezoidal distributed loads
5. Number of elements

Where do we entering the length of beam and number of elements for the purpose of accuracy in the calculations, then entering number of concentrated loads, loads values and loads locations according to their number, then entering number of uniform distributed loads and entering the value of each load, the beginning and the ending location so on according to the number of loads, as for trapezoidal distributed loads entering their number, the value of the load at the beginning and the ending and position at the beginning and ending as well, but if any of loads are equal to zero, then no values and no beginning and end location are entered, after all these steps, it is calculated the shear force and the bending moment automatically, once we press on shear force diagram button, the graphic appears on the grid,

then we press on bending moment diagram button, the graphic appears on the grid that after deleting a drawing of shear force automatically.



Chapter Five

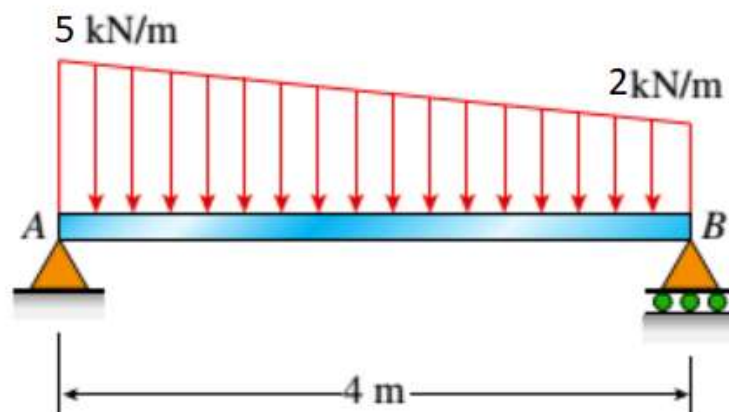
Illustrative examples of the program

Introduction

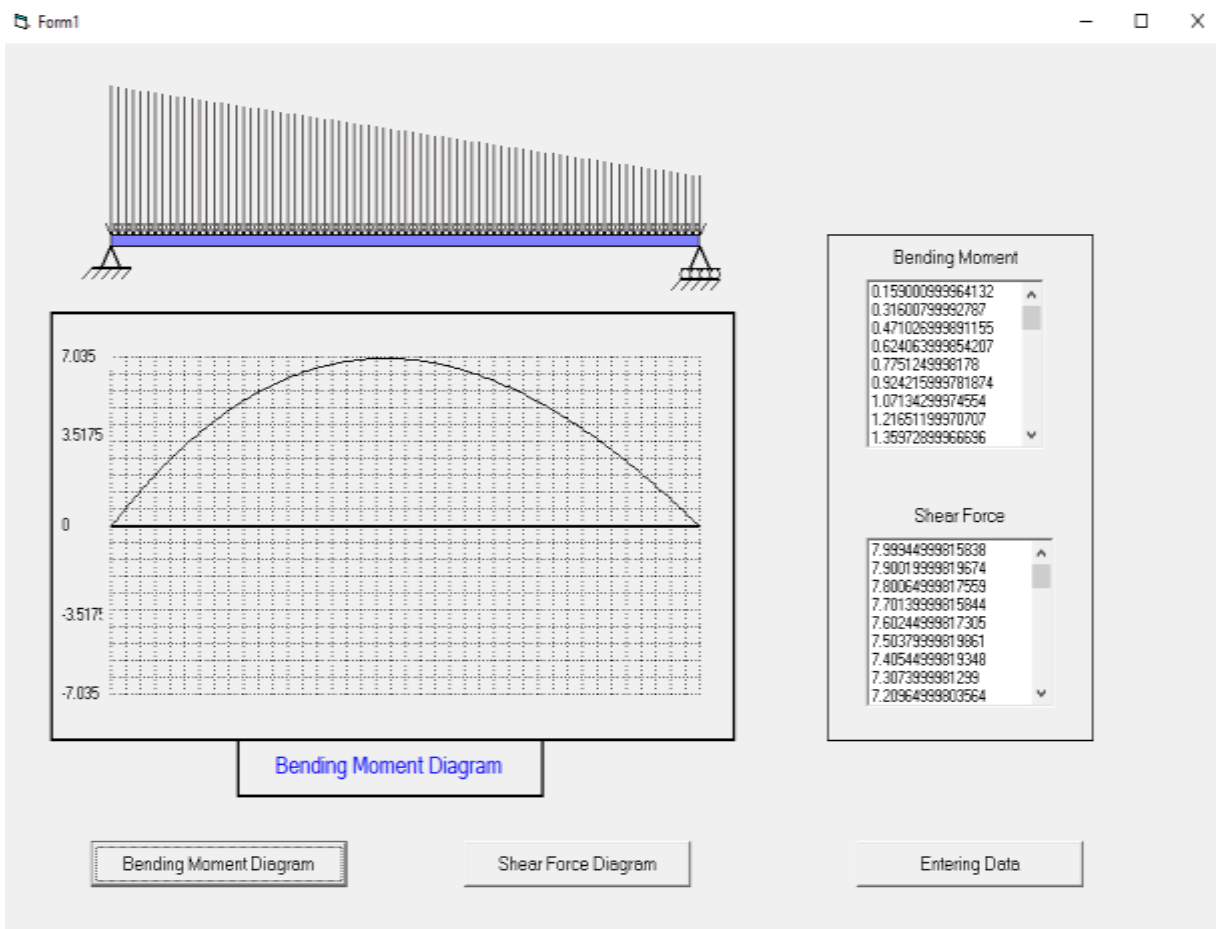
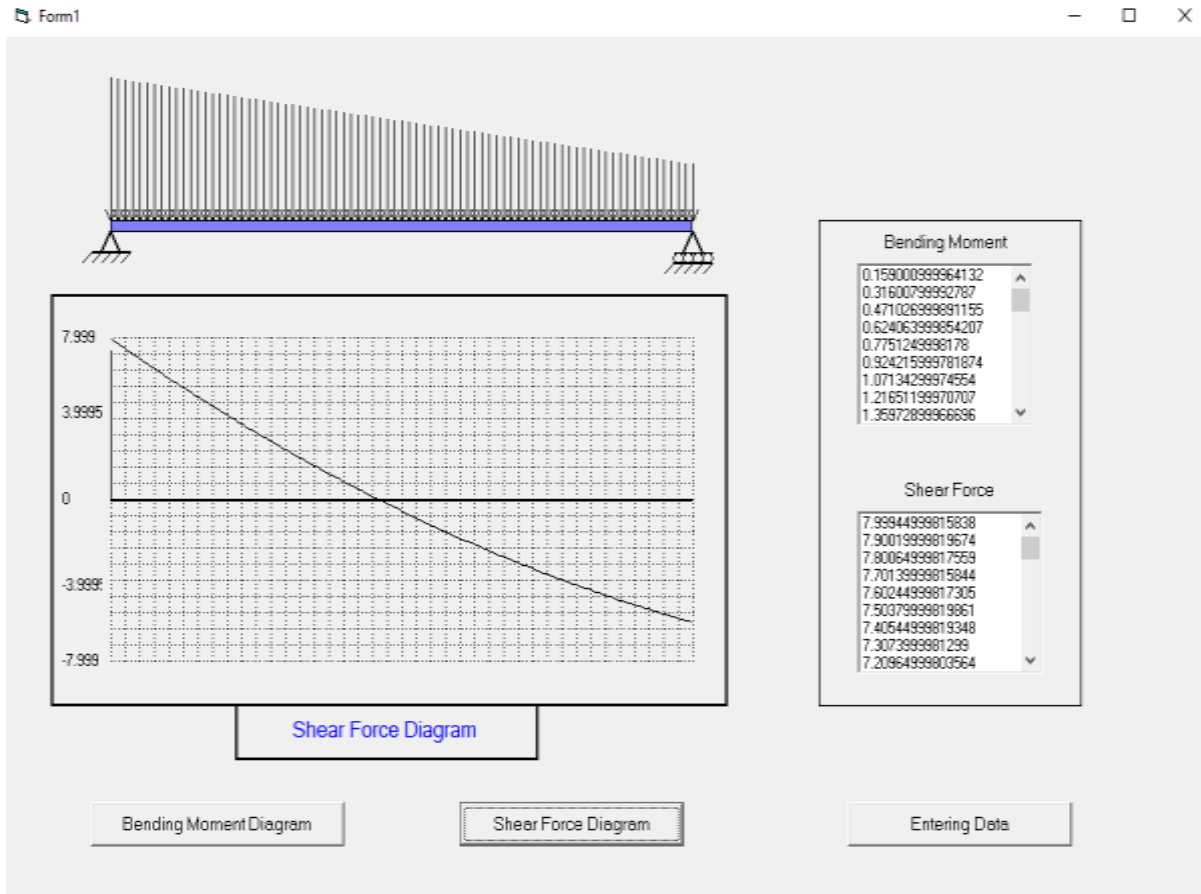
Writing the program itself is not enough to ensure that the results are correct, as the program must be tested on several pre-solved examples to make sure that the results are matched and then rely on the program to draw the shear and bending moment diagrams without any doubt

The program has been tested on more than 100 examples, so the results are exactly the match, and the next examples show that.

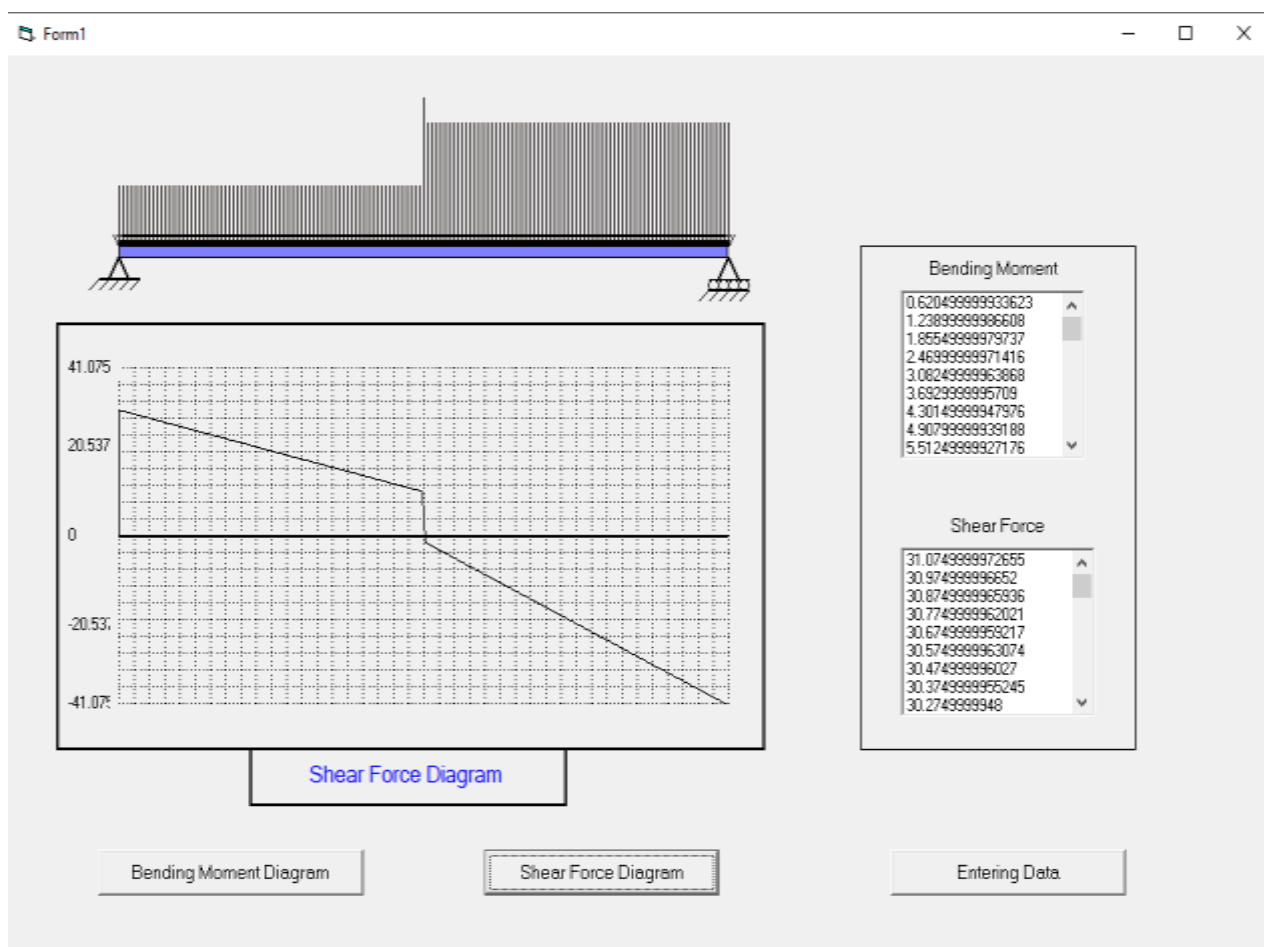
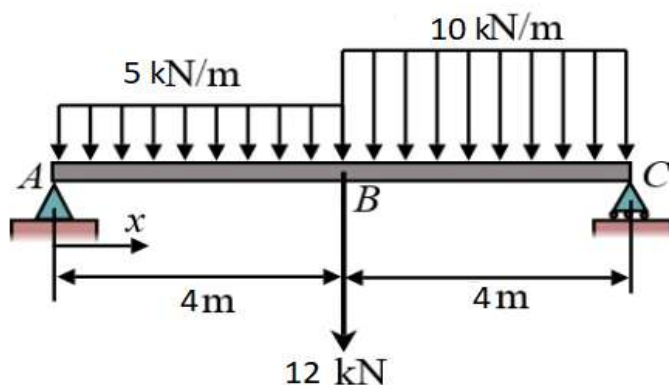
Example 1: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)

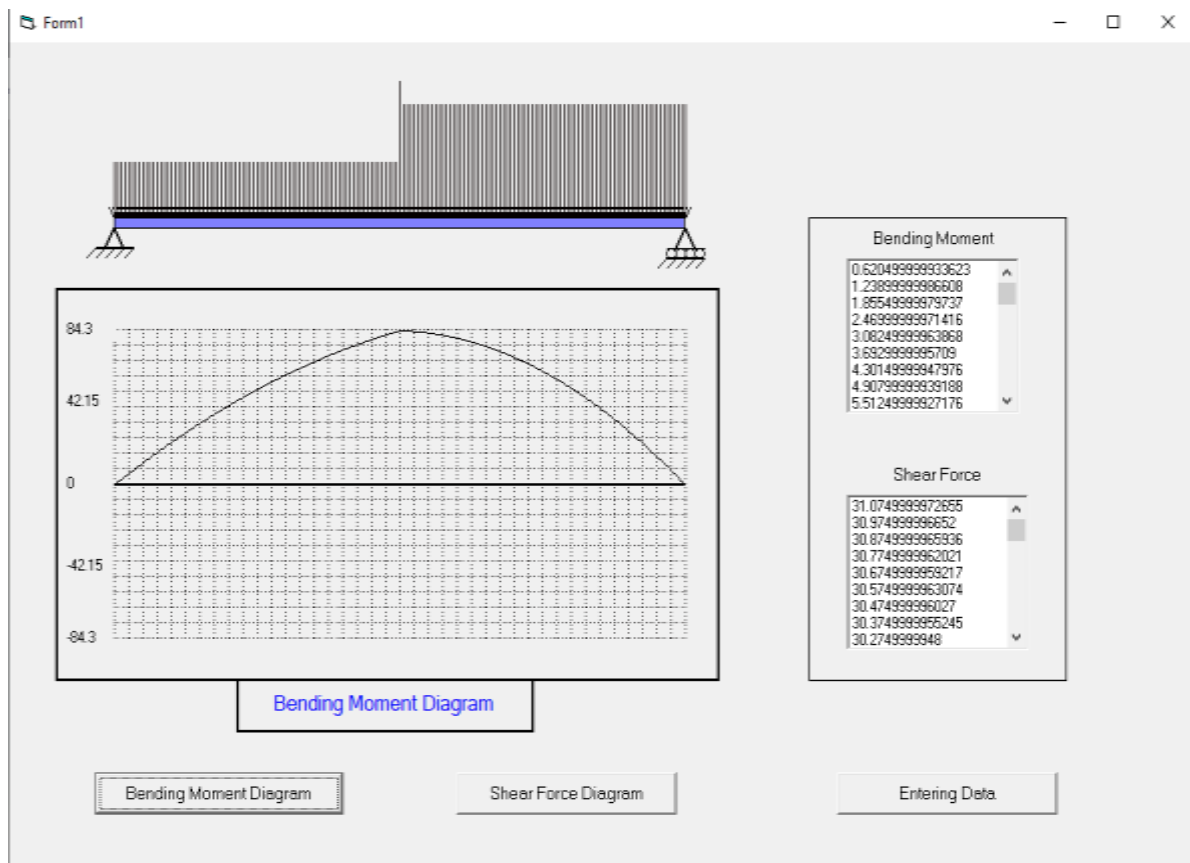


After the program was run and the information was entered, the results on the screen were as follows:

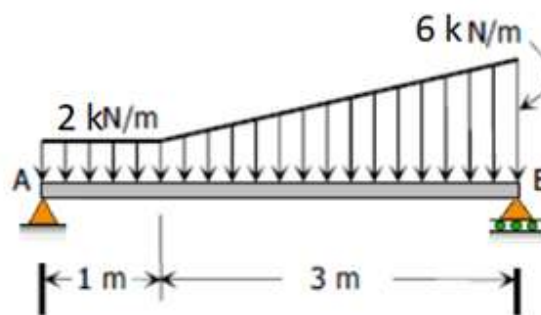


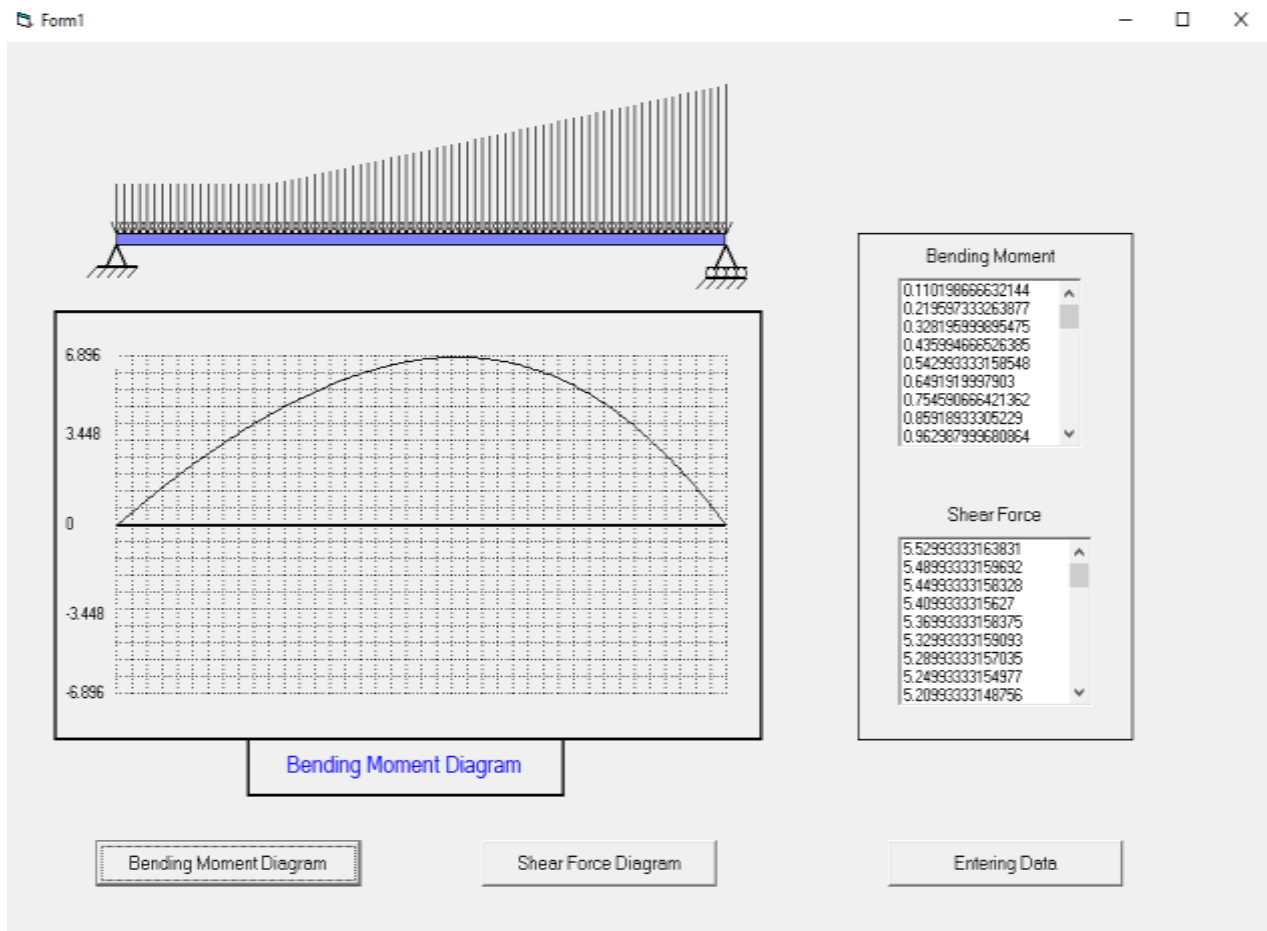
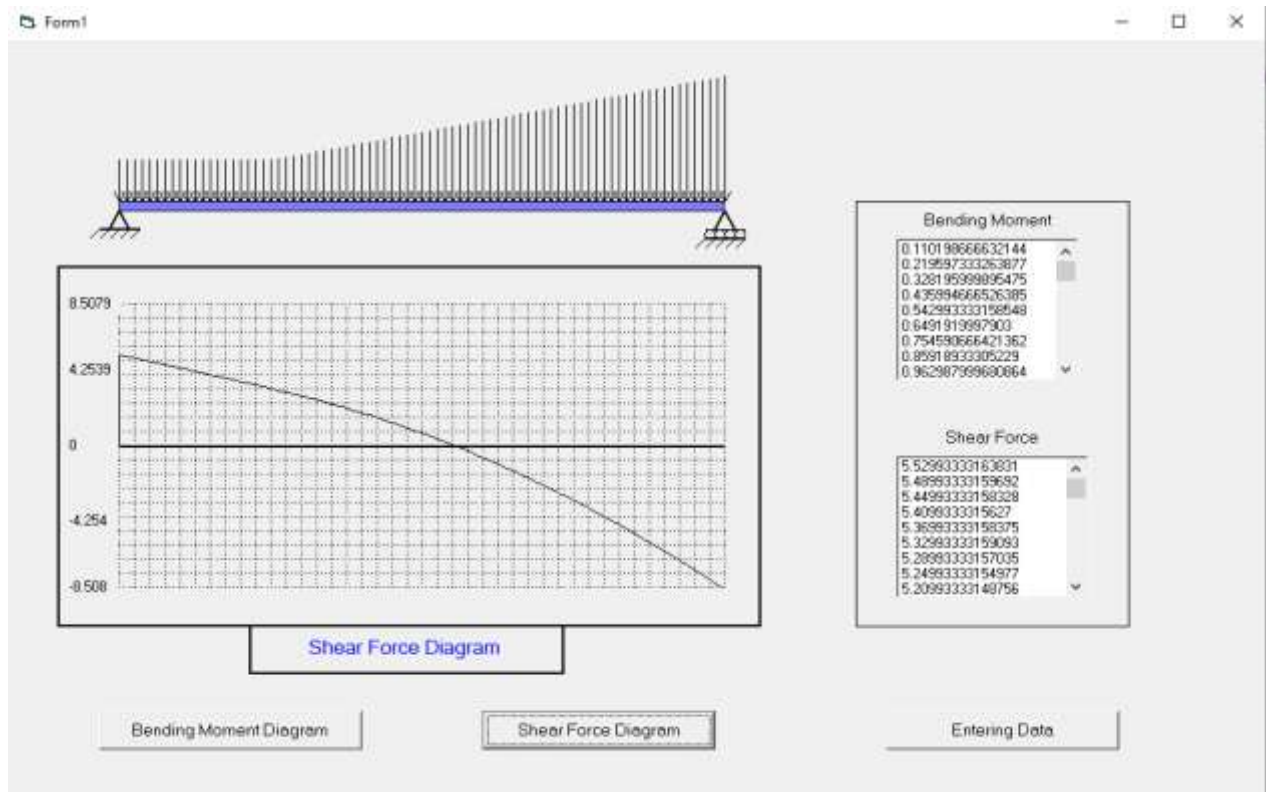
Example 2: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)



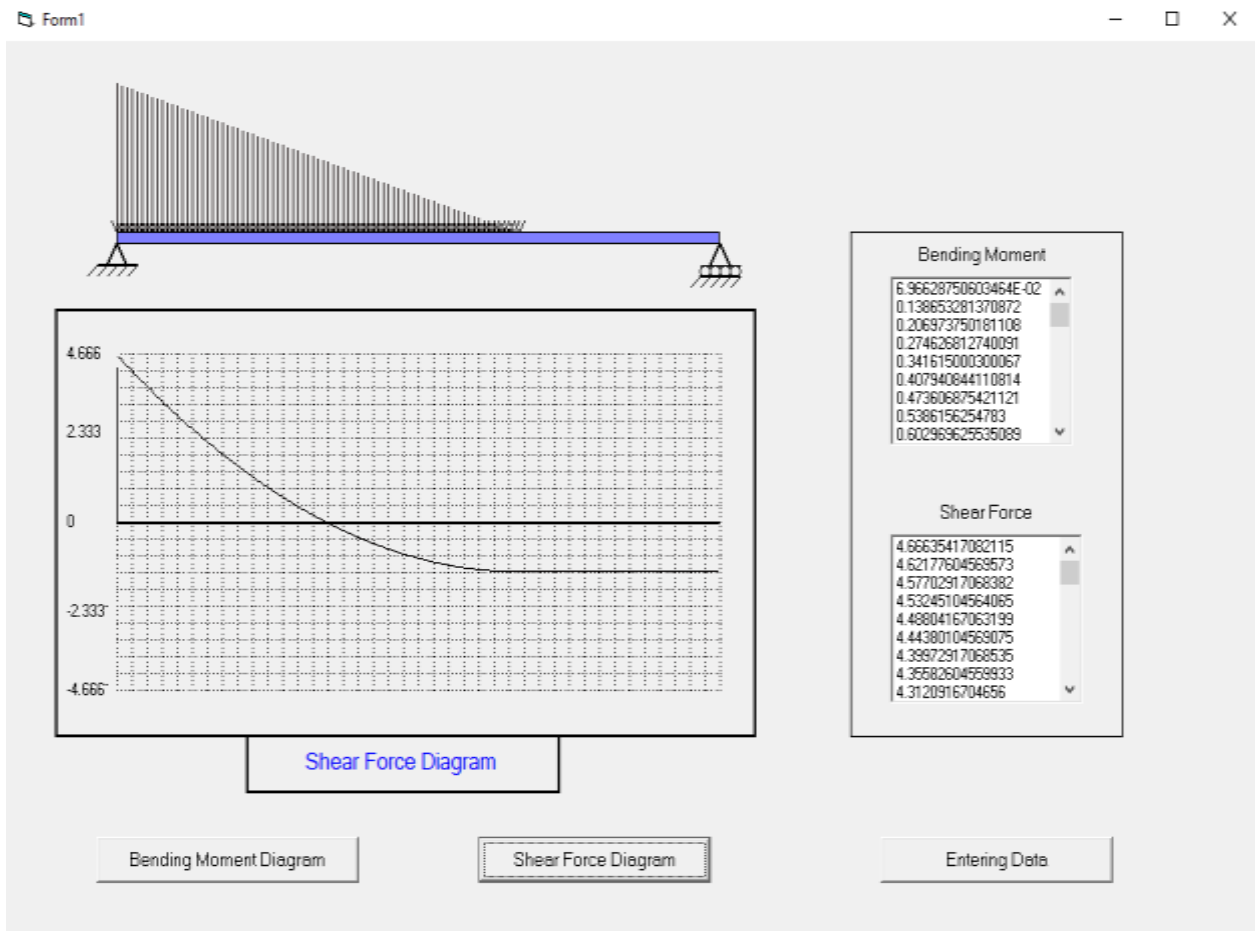
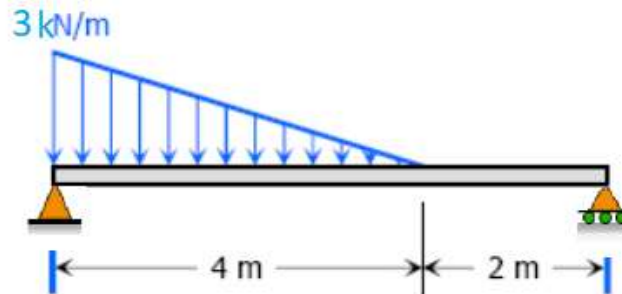


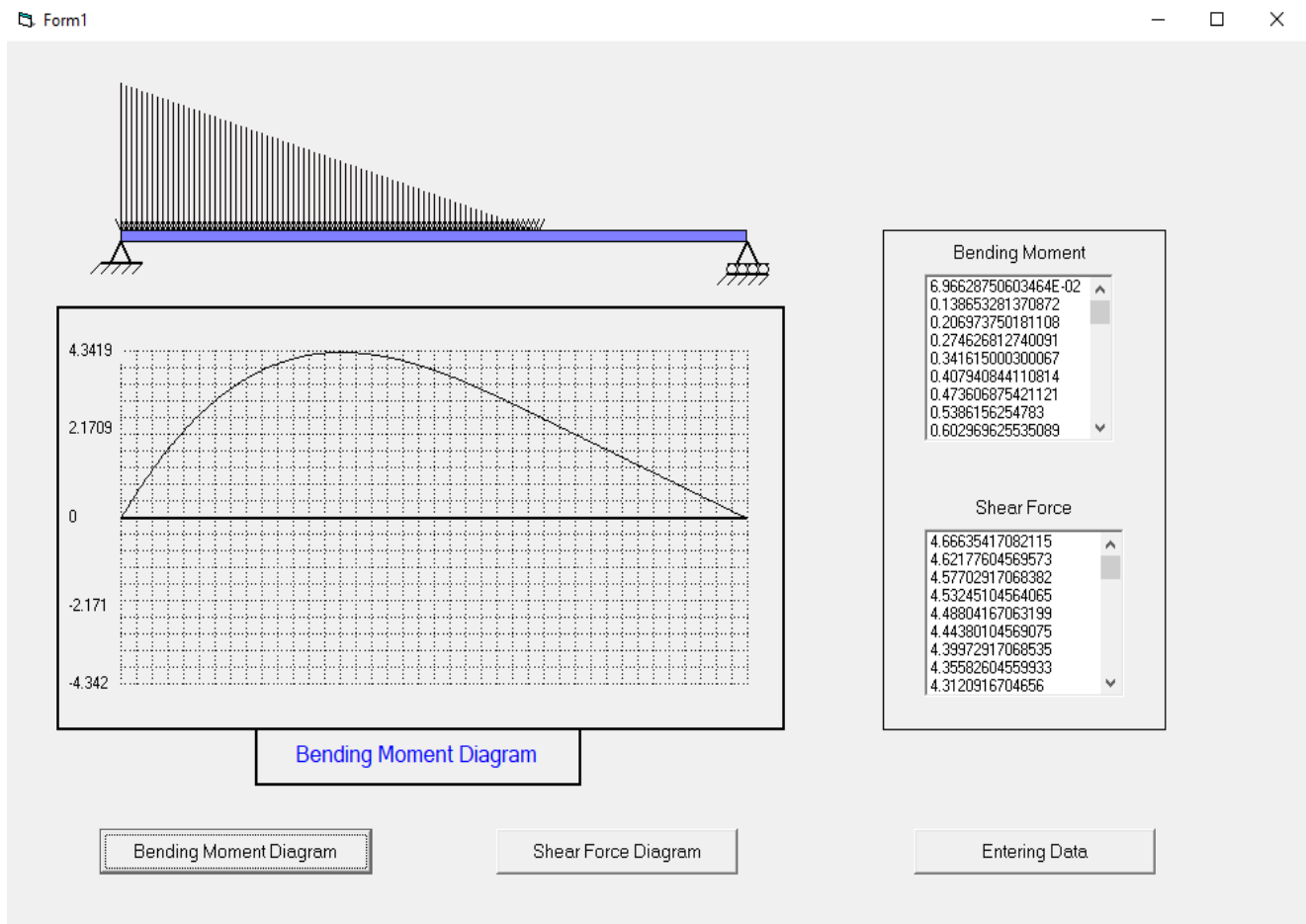
Example 3: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)



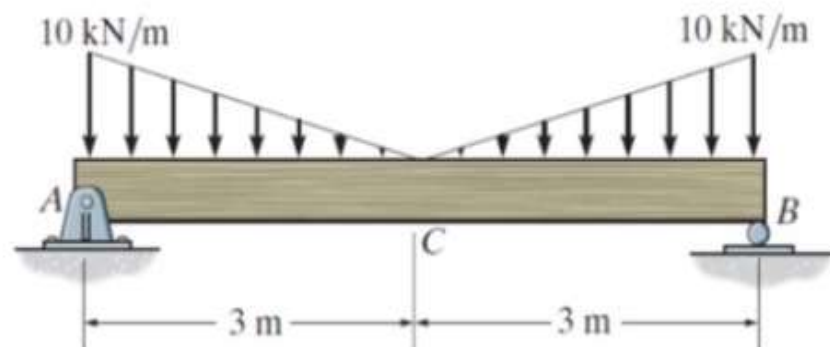


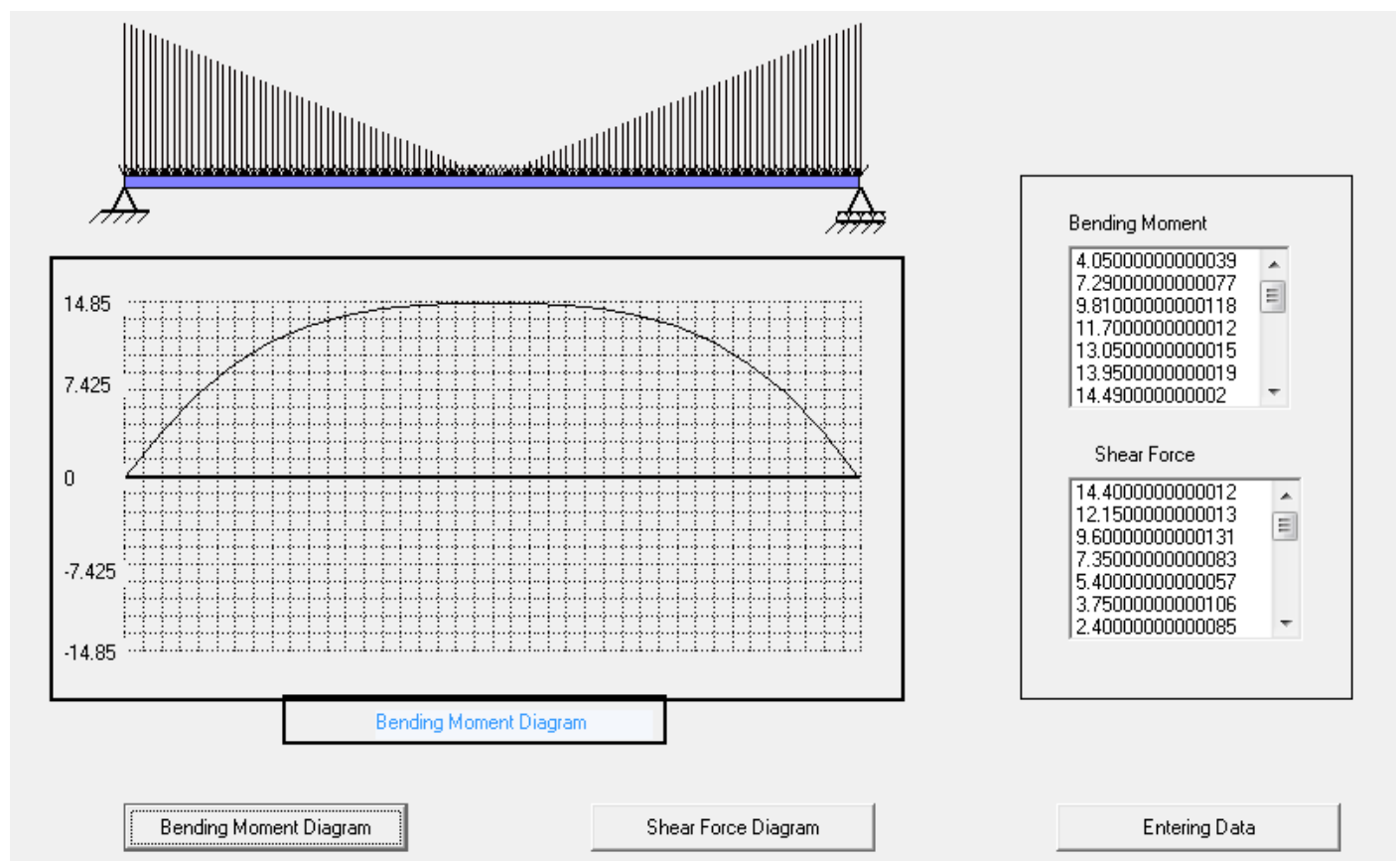
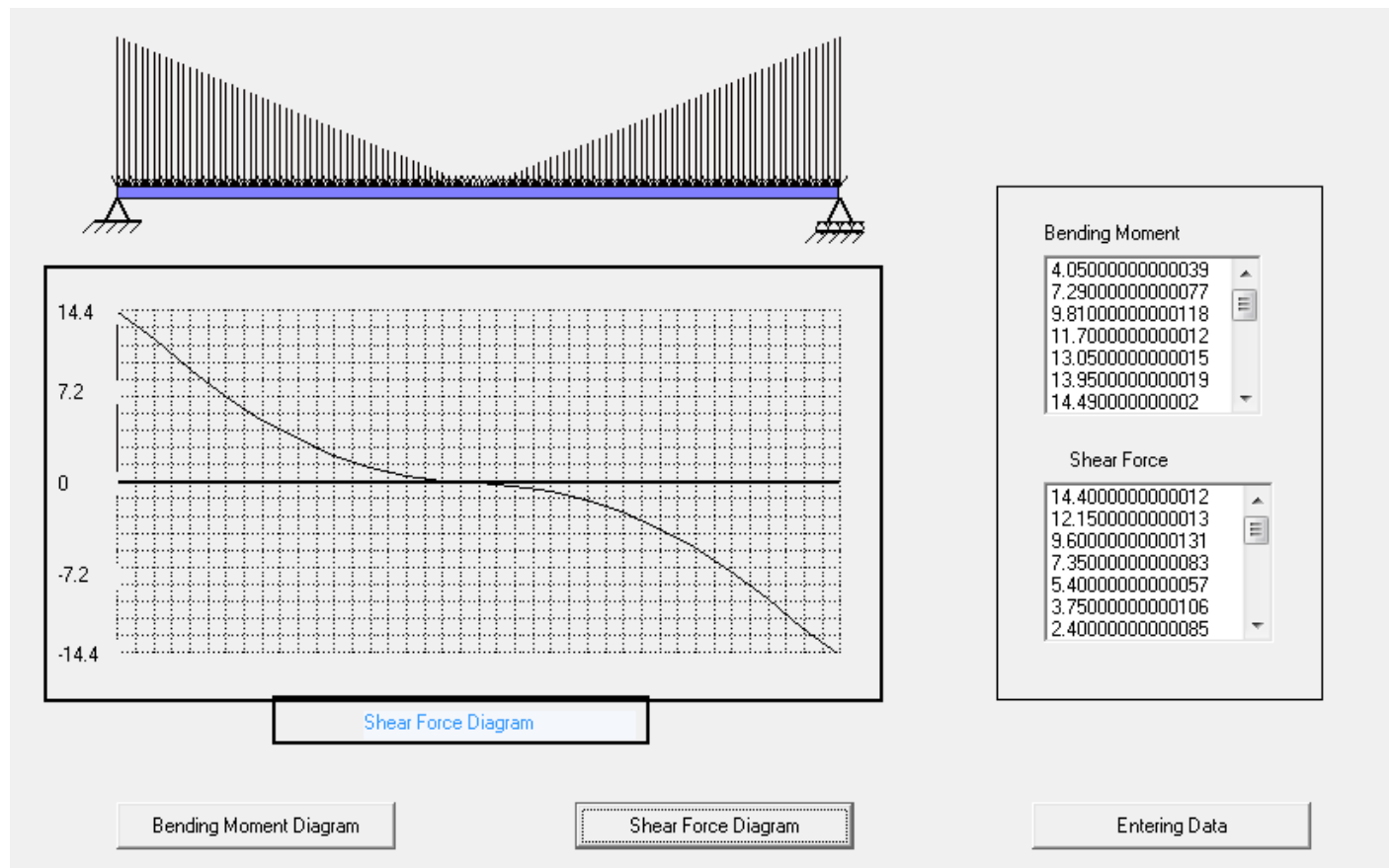
Example 4: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)



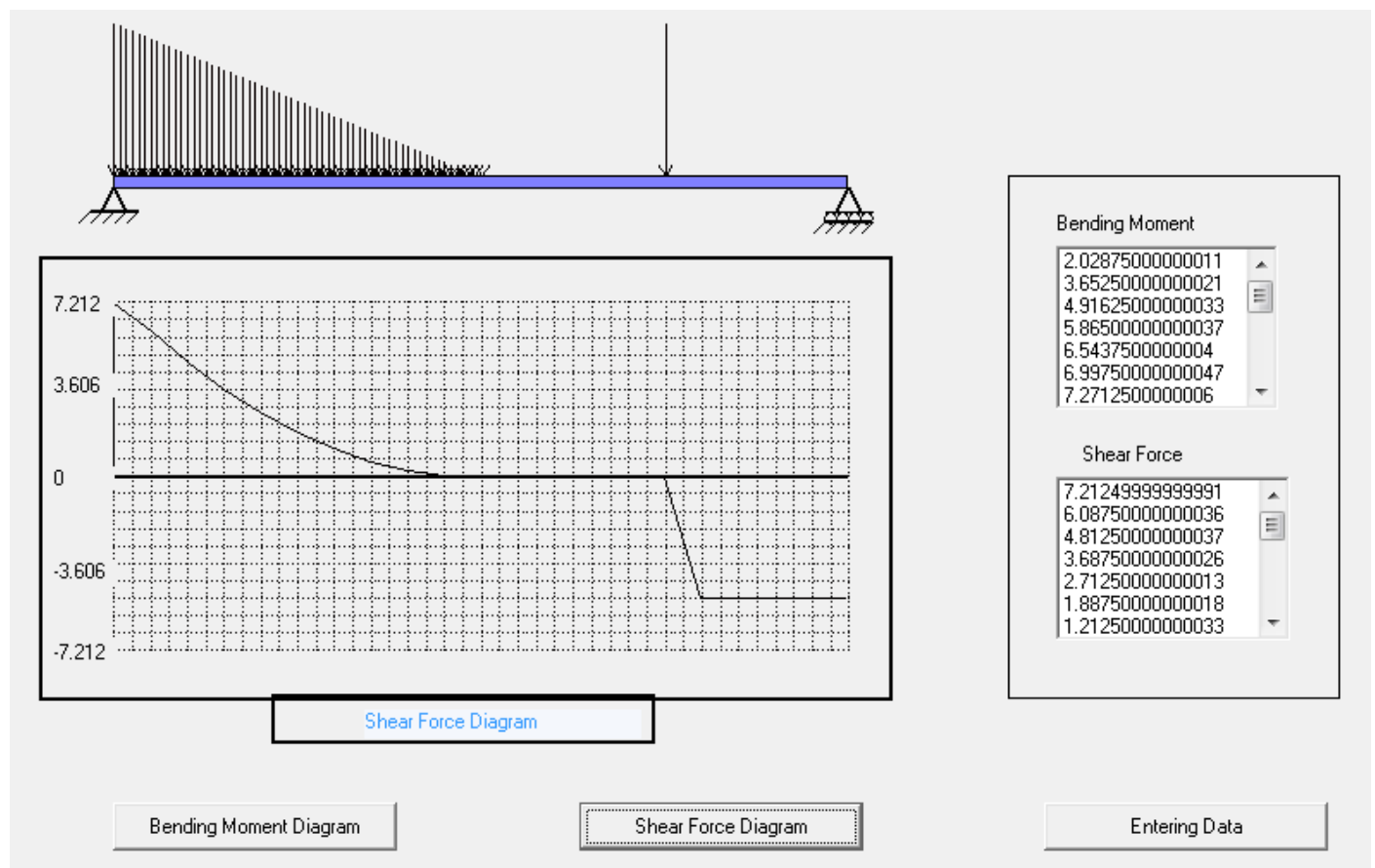
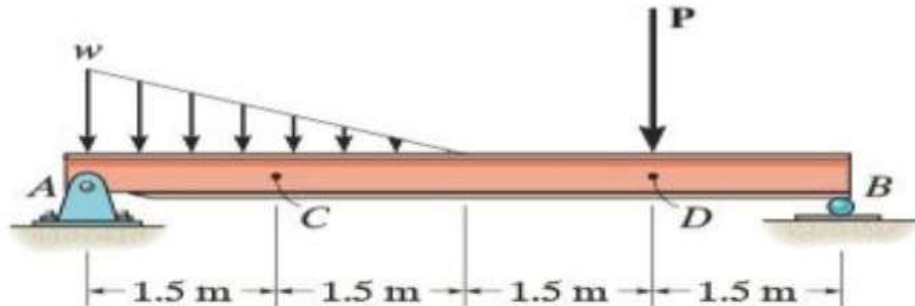


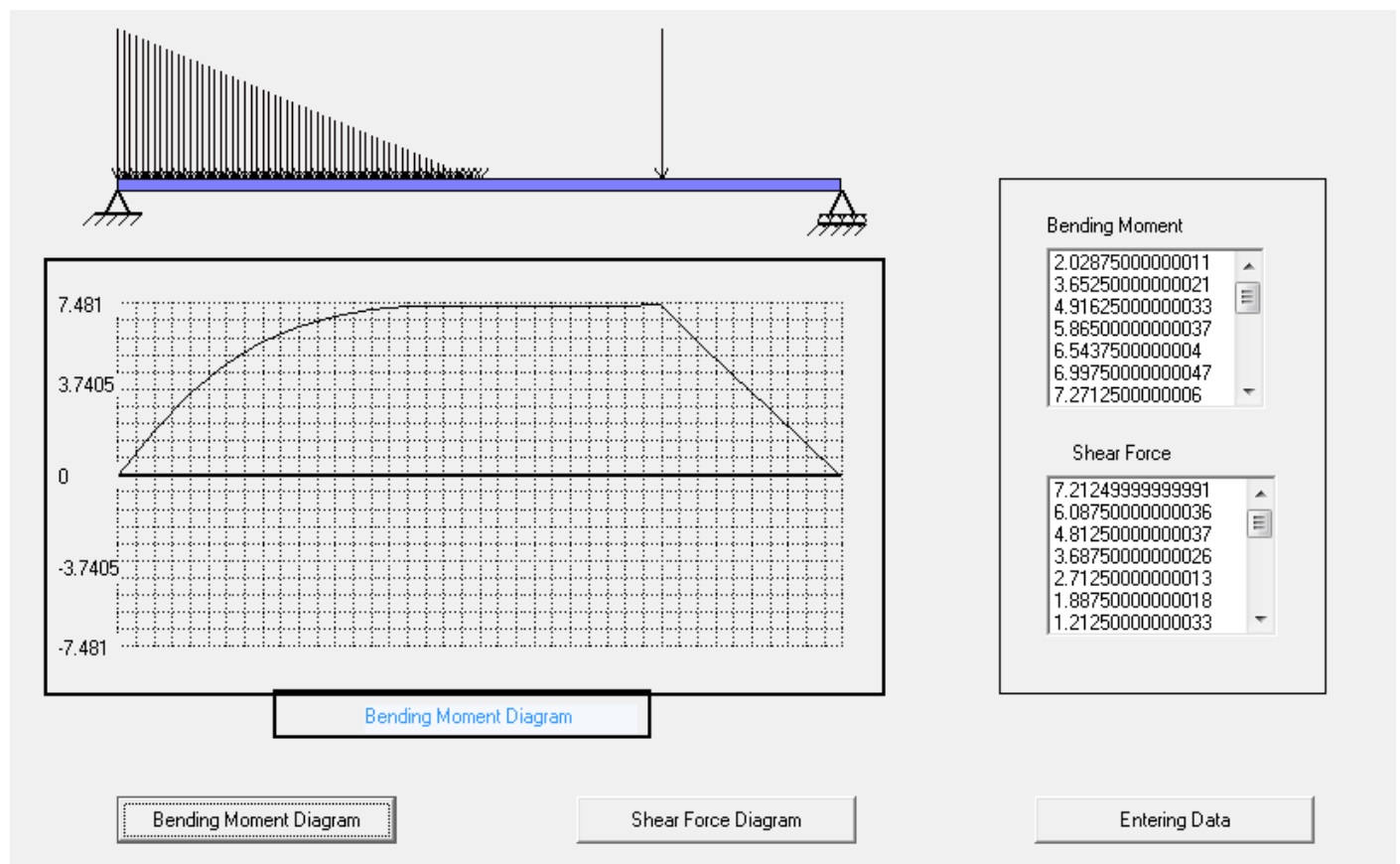
Example 5: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)



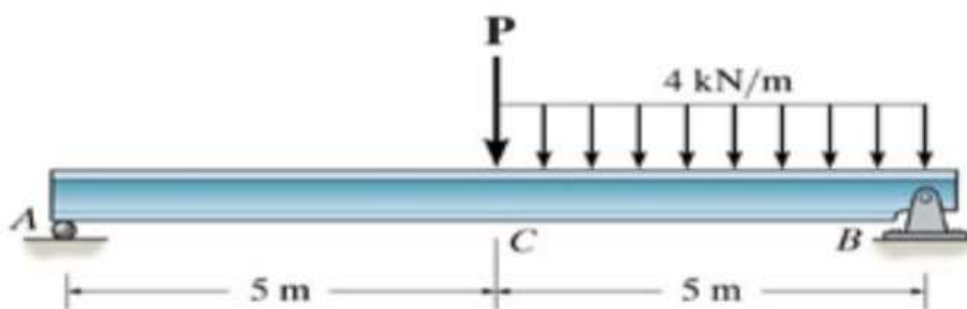


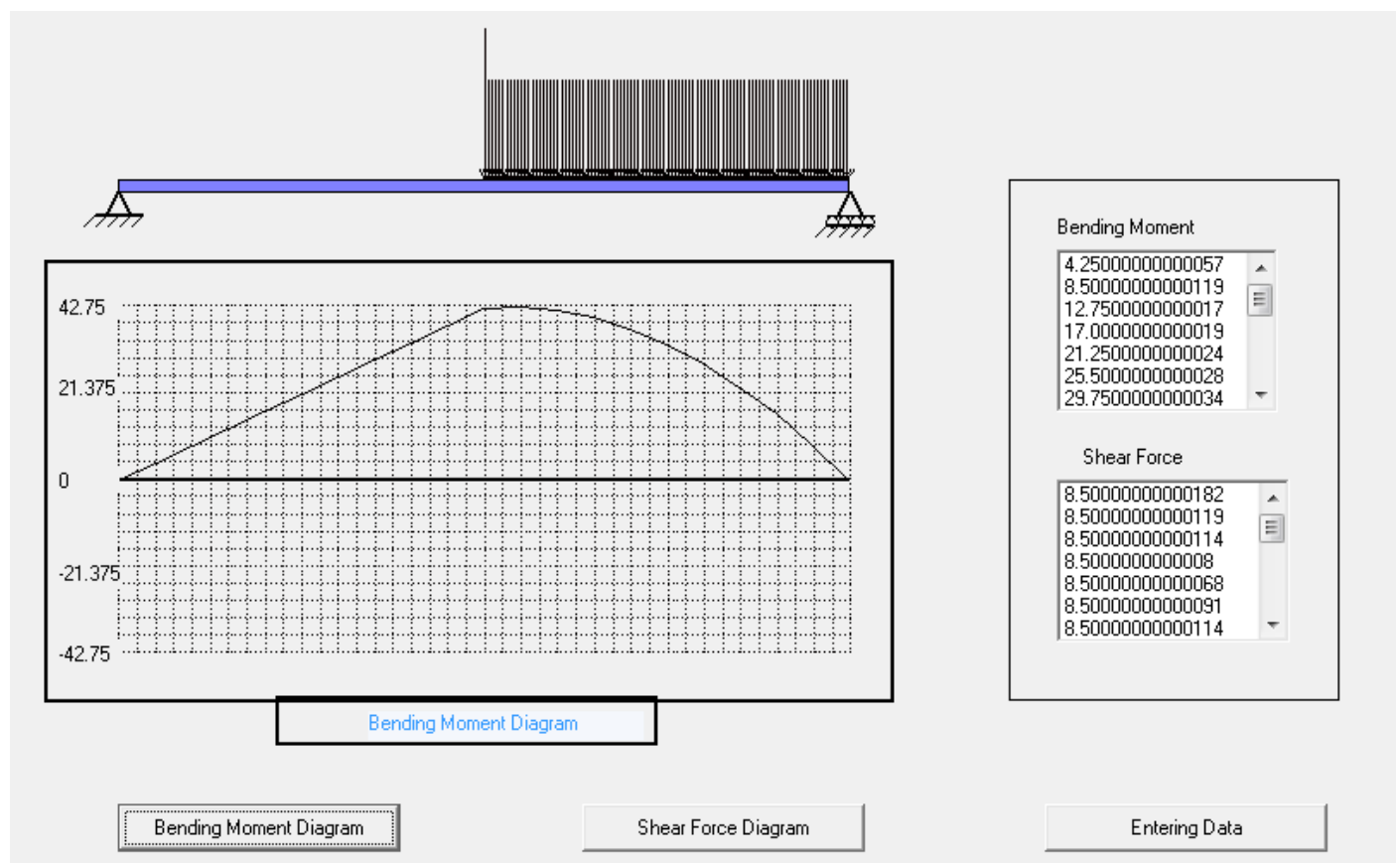
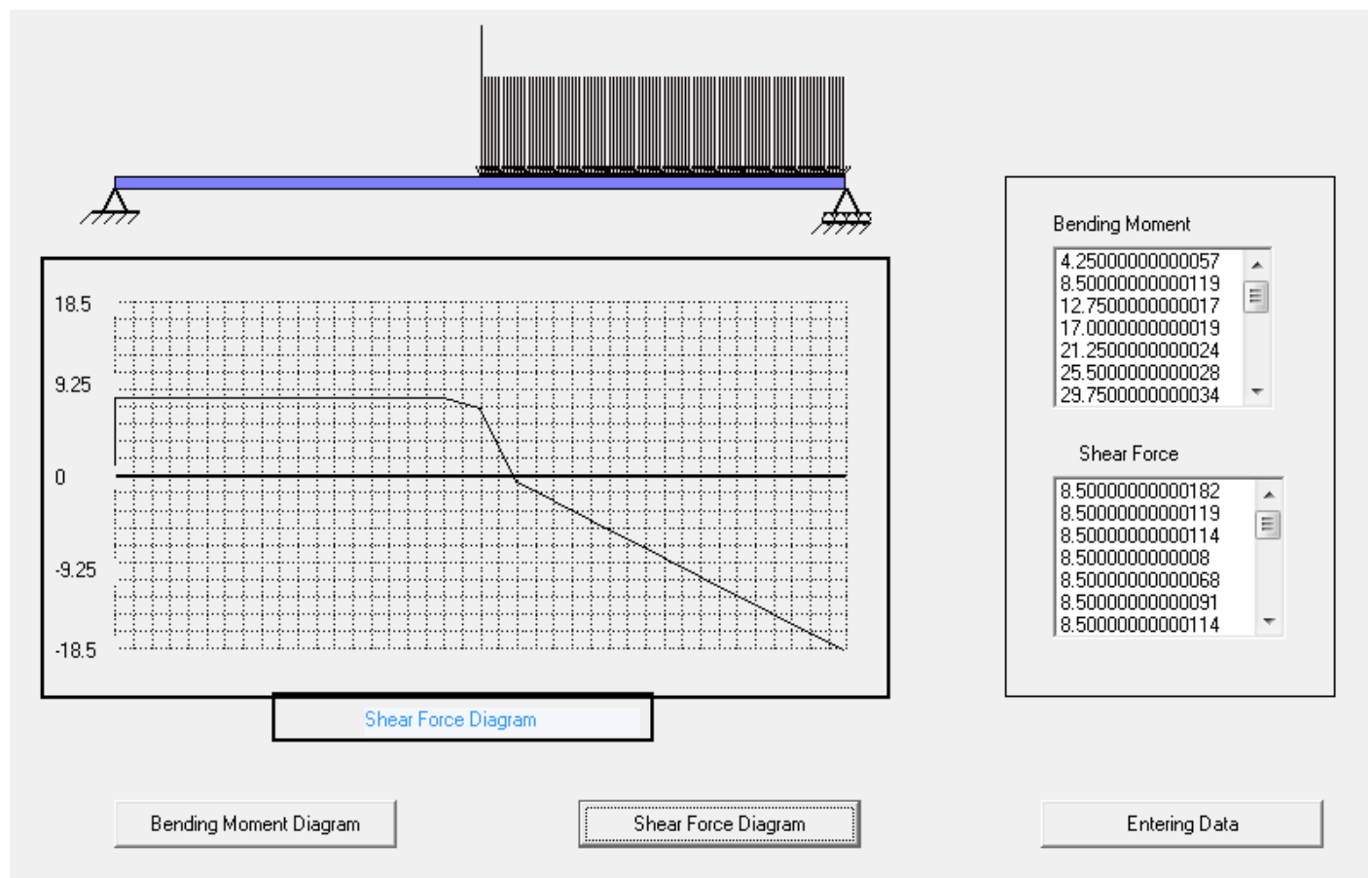
Example 6: Draw the shear force and the bending moment diagram for the simply supported beam as shown = below (EI constant), $W=5\text{KN/m}$, $P = 5\text{KN}$



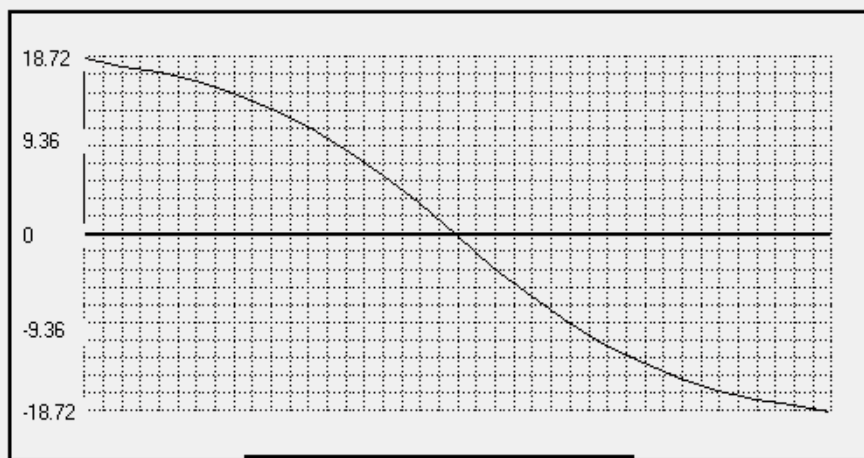
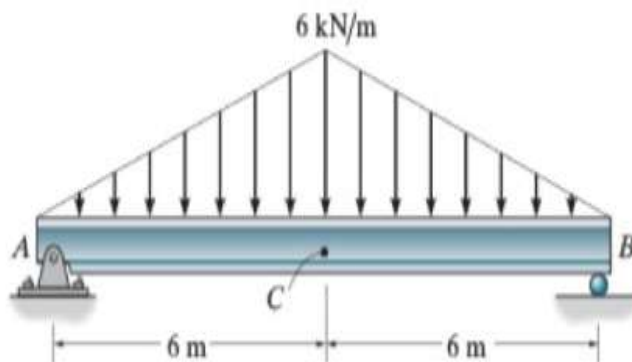


Example 7: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$), $W = 4 \text{ kN/m}$, $P = 6 \text{ kN}$





Example 8: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)



Shear Force Diagram

Bending Moment

10.8000000000017
21.3840000000032
31.5360000000049
41.0400000000006
49.6800000000064
57.2400000000079
63.5040000000092

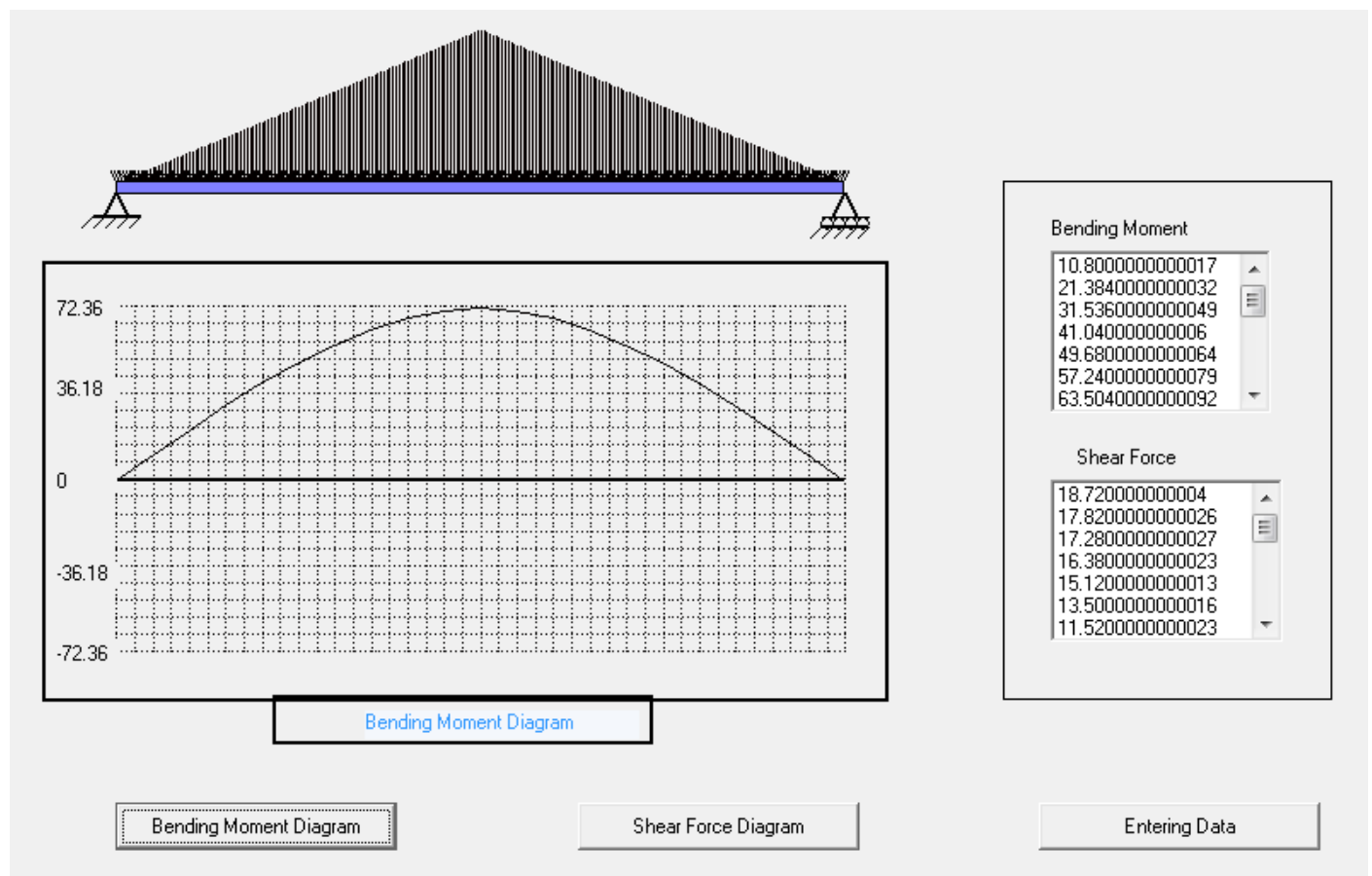
Shear Force

18.7200000000004
17.8200000000026
17.2800000000027
16.3800000000023
15.1200000000013
13.5000000000016
11.5200000000023

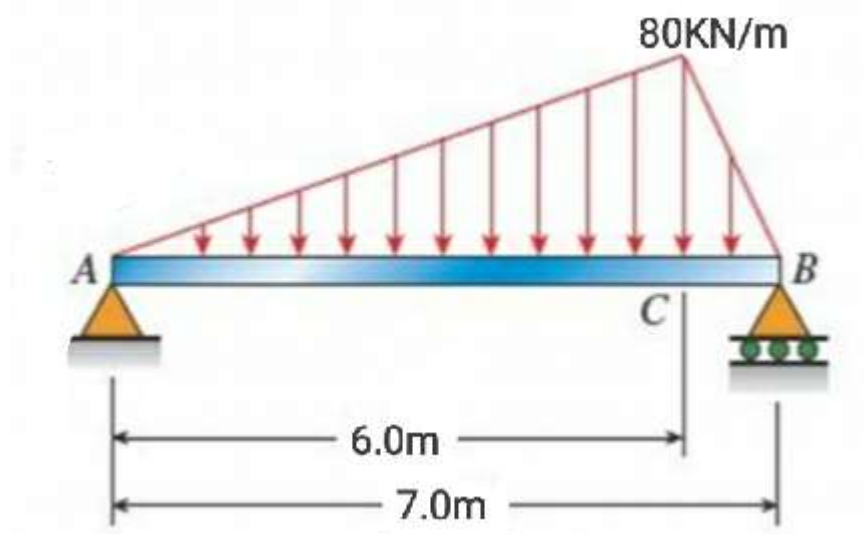
Bending Moment Diagram

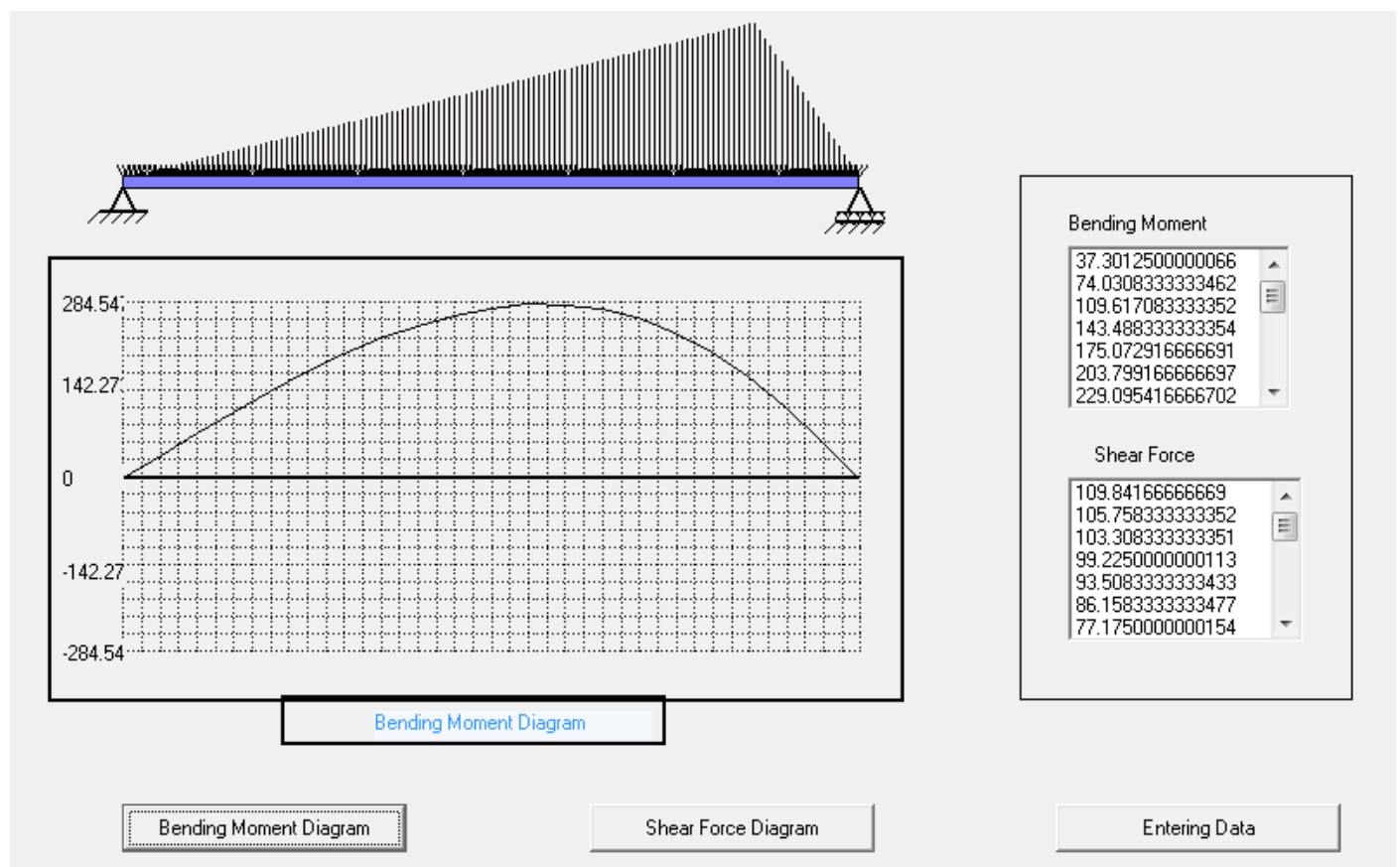
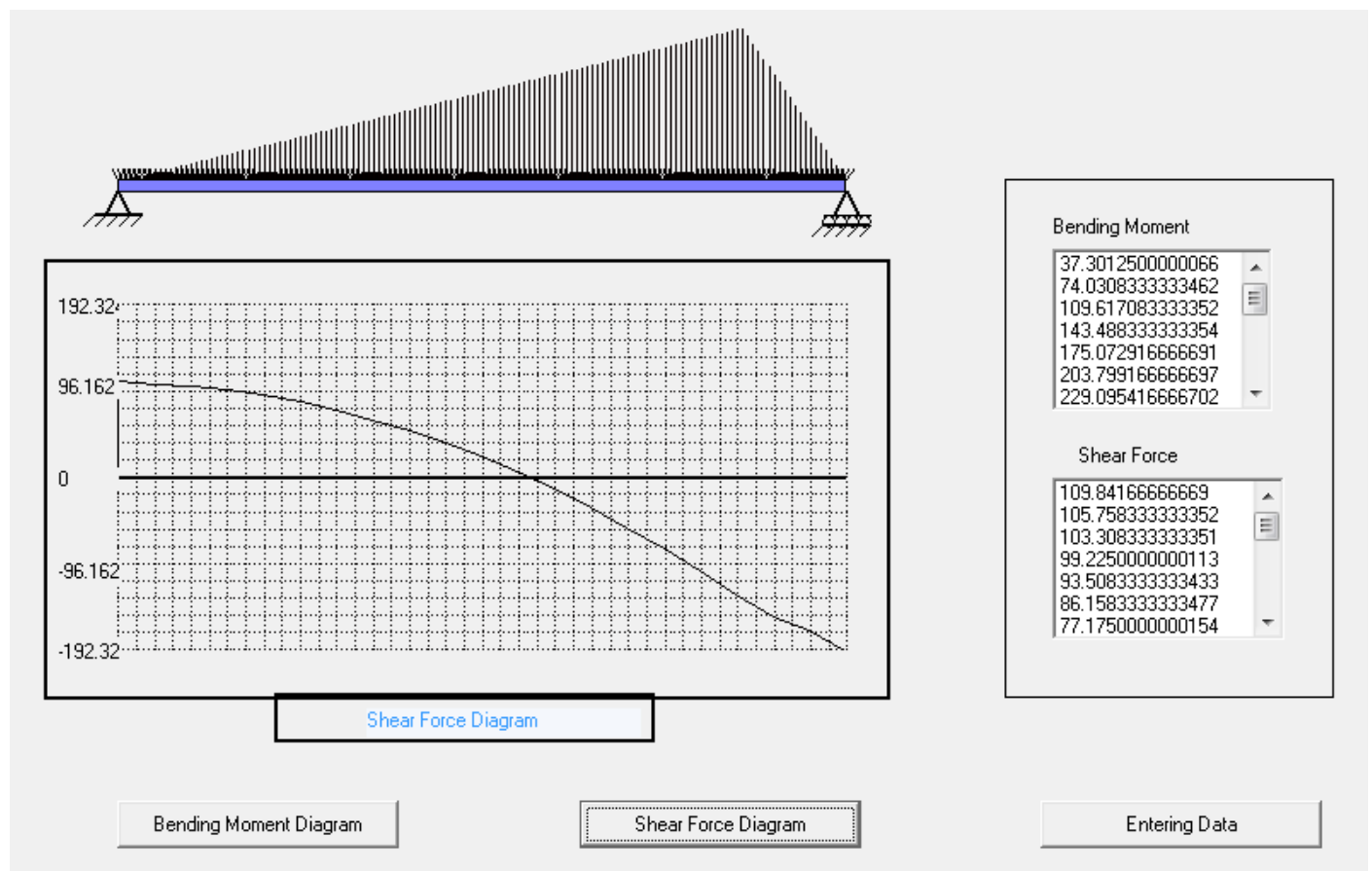
Shear Force Diagram

Entering Data

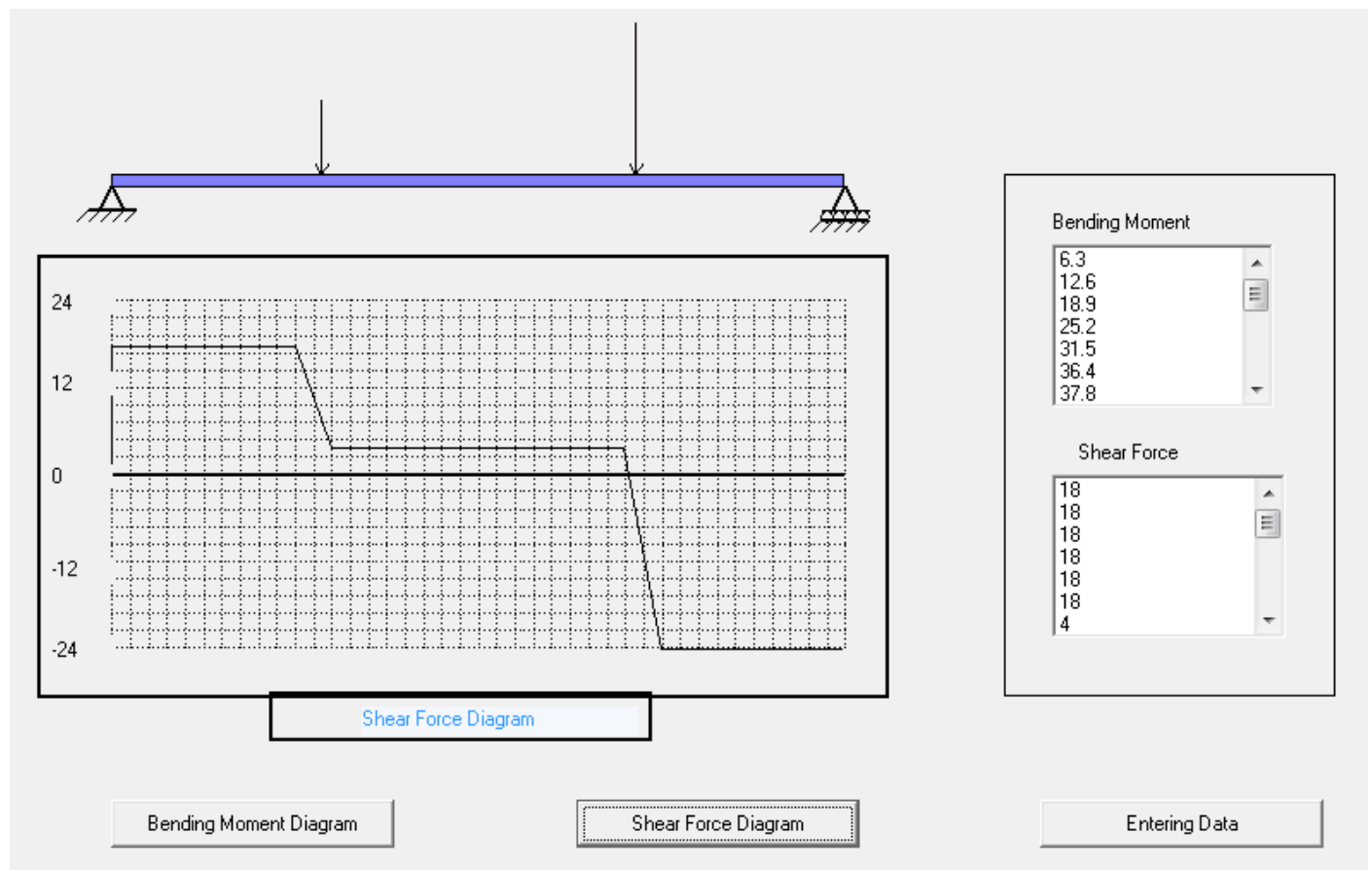
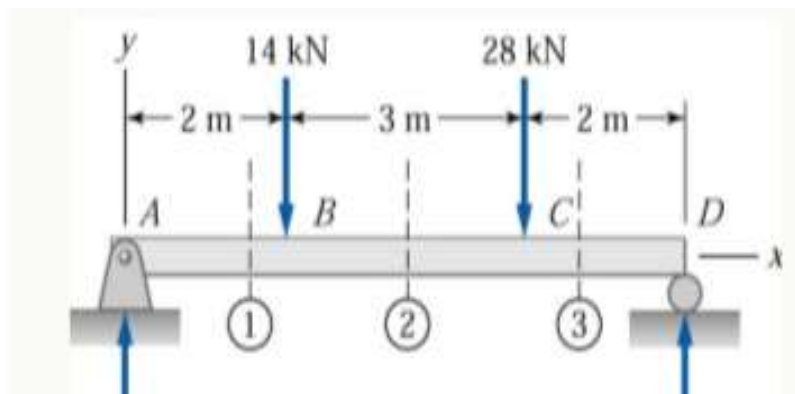


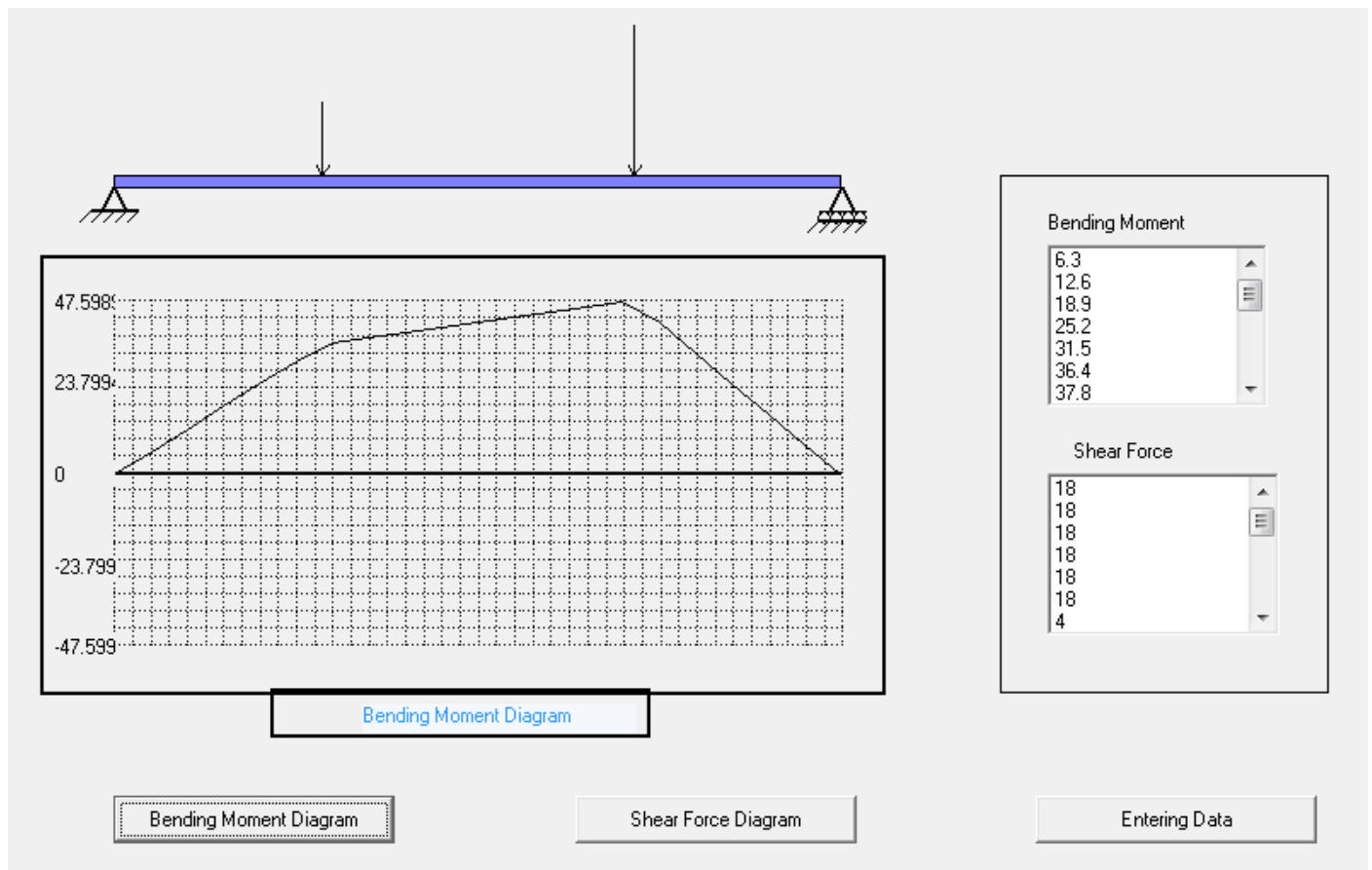
Example 9: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)





Example 10: Draw the shear force and the bending moment diagram for the simply supported beam as shown below ($EI = \text{constant}$)





Program Steps

```

Dim n, ns, w(1000), a(10), b(10), wt(1000), m(3000,3000), y(3000), yp(3000), R(3000),
Rp(3000), MB(3000), V(3000), ws(1000), w1(100), w2(100), ass(100), bs(100), P(10),
Vp(1000), ap(10), L, Pmax, Vmax, Mmax, ne, h, MBp(1000), np As Double
Private Sub Command1_Click()
y(0)=0
EI=1
'###Entering of distributed loads###
L=Val(InputBox("enter length of beam"))
n=Val(InputBox("enter number of distributed loads"))
For i = 1 To n
w(i) = Val(InputBox("enter value of distributed loads",i))

```

```
a(i) = Val(InputBox("enter location of the beginning",i))
b(i) = Val(InputBox("enter location of ending",i))
If Pmax < Abs(w(i)) Then Pmax = Abs(w(i))
Next I
ne = InputBox("enter number of elements")
h = L/ne
For i = 0 To ne
  For k = 1 To n
    If a(k) <= h * I Then wt(i) = (wt(i)+w(k))
  Next k
Next i
'###Entering of trapezoidal loads###
ns = Val(InputBox("enter number of trapezoidal loads"))
For i = 1 To ns
  w1(i) = Val(InputBox("enter value of trapezoidal load in the beginning",i))
  w2(i) = Val(InputBox("enter value of trapezoidal load in the ending",i))
  ass = Val(InputBox("enter location of the beginning",i))
  bs = Val(InputBox("enter location of the ending",i))
  If Pmax < Abs(w1(i)) Then Pmax = Abs(w1(i))
  If Pmax < Abs(w2(i)) Then Pmax = Abs(w2(i))
Next i
For i = 0 To ne
  For k = 1 To ns
    If ass(k) <= h * i And bs(K) >= h * i Then ws(i) = (w2(k) - w1(k))/(bs(k) - ass(k)) * (h * i -
    ass(k)) + w1(k)
  Next k
Next i
For i = 1 To ne
  wt(i) = wt(i) + ws(i)
```

Next i

'###Entering of Concentrated Loads###

np = Val(InputBox("enter number of concentrated load"))

For i = 1 To np

P(i) = Val(InputBox("enter value of cocetrated load",i))

ap(i) = Val(InputBox("enter locatin of concentrated load",i))

If Pmax < Abs(P(i)) Then Pmax = Abs(P(i))

Next i

'###Calculation of Shear Force###

For i = 1 To np

For k = 0 To ne

x = h * k

If x <= ap(i) Then Vp(k) = Vp(k) – P(i) * (L- ap(i))/L

If x > ap(i) Then Vp(k) = Vp(k) + P(i) * ap(i)/L

Next k

Next I

'###Calculation of Bending Moment###

For i = 1 To np

For k = 0 To ne

x = h * k

If x <= ap(i) Then MBp(k) = MBp(k) + P(i) * (1- ap(i)/L) * x

If x > ap(i) Then MBp(k) = MBp(k) + P(i) * ap * (1-x/L)

Next k

Next i

'###Calculate of Matrix###

For i = To ne – 3

m(i +2, i)=1

m(i, i + 2) = 1

Next i

```
For i = To ne - 2
m(i + 1, i) = -4
m(i, i + 1) = -4
Next i
For i = 2 To ne - 2
m(i, i) = 6
Next i
m(1, 1) = 5
m(ne - 1, ne - 1) = 5
For i = 1 To ne - 1
R(i) = wt(i) * h ^ 4/EI
Next i
For i = 3 To ne - 1
kk = m(i, I - 2)/m(i - 1, i - 2)
For k = i - 2 To i + 1
m(i, k) = m(i, k) - m(i - 1, k) * kk
Next k
R(i) = R(i) - R(i - 1) * kk
Next i
For i = 2 To ne - 1
kk = m(i, i - 1)/m(i - 1, i - 1)
For k = i - 1 To i + 1
m(i, k) = m(i, k) - m(i - 1, k) * kk
Next k
R(i) = R(i) - R(i - 1) * kk
Next i
For i = ne - 1 To 1 Step - 1
s = 0
For k = ne - 1 To I Step -1
```

```

s = s+ m(i, k+1) * y(k + 1)
Next k
y(i) = 1/(m(i, i) * (R(i) - s)
Next i
'###Print Values of Sheare Force and Bending Moment###
For i = 1 To ne - 1
MB(i) = -(y(i - 1) - 2 * y(i) + y(i +1))/h^2
MB(i) = MB(i) + MBp(i) If Abs(MB(i)) > Mmax = Abs(MB(i))
Next i
For i = 1 To ne - 1
List2.Addltem MB(i)
Next i
V(1) = 1/(2 * h ^ 3) * (-y(1) + 2 * y(2) - y(3))
V(1) = V(1) - Vp(1) If Abs(V(1)) > Vmax Then Vmax = Abs(V(1))
V(ne - 1) = 1/(2 * h ^ 3) * (y(ne - 3) - 2 * y(ne - 2) + y(ne - 1))
V(ne - 1) = V(ne - 1) - Vp(ne - 1)
If Abs(V(ne - 1)) > Vmax Then Vmax = Abs(V(ne - 1))
V(0) = 1/(2 * h ^ 3) * (-18 * y(1) + 24 * y(2) - 14 * y(3) +3 * y(4))
V(0) = V(0) - Vp(0)
If Abs(V(0)) > Vmax Then Vmax = Abs(V(0))
V(ne) = 1/(2 * h ^3) * (-3 * y(ne -4) + 14 * y(ne -3) - 24 * y(ne - 2) + 18 * y(ne - 1))
V(ne) = V(ne) - Vp(ne) If Abs(V(ne) > Vmax Then Vmax = Abs(V(ne))
For i =2 To ne - 2
V(i) = 1/(2 * h ^ 3) * (y(i - 2) - 2 * y(i - 1) + 2 * y(i +1) - y(i +2))
V(i) = V(i) - Vp(i) If Abs(V(i)) > Vmax Then Vmax = Abs(V(i))
Next i
For i = 0 To ne
List3.Addltem V(i)
Next i

```

End Sub

Private Sub Data1_Validate(Action As Integer, Save As Integer)

End Sub

Private Sub Command2_Click()

Cls

Label4.Caption = "Sheare Force Diagram"

'###Entering Data to Draw Shear Force Diagram###

For kk = 0 To 20

For ff = 0 To 7200 Step 50

PSet (1320 + ff, 3340 + kk * 180),2

Next ff

Next kk

For kk =0 To 40

For ff = 0 To 3600 Step 50

PSet(1320 + kk * 180, 3340 + ff), 2

Next ff

Next kk

Fa = Int(4/L * 500)

PSet(1320, 5160), 2

j = -1

If Vmax = 0 Then Vmax = 1

For k = 0 To ne

x = k * h * Fa

j = j + 1

xx = 1320 + 7180 * (x/Fa)/L

Line -(xx, 5160 – 1800 * V(j)/Vmax), 2

Next k

Vmax = Int(Vmax * 1000)/1000

```

For i = 0 To 4
Label3(i).Caption = Int(Vmax * (10 - 5 * i) * 1000)/10000
Next i
For i = 1 To np
If P(i) >=0 Then
Line (1320 + ap(i) * 7200/L, 2040)-(1320 + ap(i) * 7200/L, 2040 - p(i) * 1600/Pmax), 8
Line (1320 + ap(i) * 7200/L, 2040)-(1400 + ap(i) * 7200/L, 1900), 2
Line (1320 + ap(i) * 7200/L, 2040)-(1400 + ap(i) * 7200/L - 150, 1900), 2
Else
Line (1320 + ap(i) * 7200/L, 2040)-(1320 + ap(i) * 7200/L, 2040 + p(i) * 1600/Pmax), 8
Line (1320 + ap(i) * 7200/L, 2040 + P(i) * 1600/Pmax)-(1240 + ap(i) * 7200/L, 2140 + p(i)
* 1600/Pmax), 2
Line (1320 + ap(i) * 7200/L, 2040 + P(i) * 1600/Pmax)-(1400 + ap(i) * 7200/L, 2140 +p(i) *
1600/Pmax), 2
End If
Next i
For i =1 To n
If w(i) >=0 Then
For x = a(i) To b(i) Step 0.05
Line (1320 + x * 7200/L, 2040)-(1320 + x * 7200/L, 2040 - w(i) * 1600/Pmax), 8
Line (1320 + x * 7200/L, 2040)-(1400 + x * 7200/L, 1900), 2
Line (1320 + x * 7200/L, 2040)-(1400 + x * 7200/L - 150, 1900), 2
Next x
Else
For x = a(i) To b(i) Step 0.05
Line (1320 + x * 7200/L, 2040)-(1320 + x * 7200/L, 2040 + w(i) * 1600/Pmax), 8
Line (1320 + x * 7200/L, 2040 + w(i) * 1600/Pmax)-(1240 + x * 7200/L, 2140 + w(i) *
1600/Pmax), 2

```

Line (1320 + x * 7200/L, 2040 + w(i) * 1600/Pmax)-(1400 + x * 7200/L, 2140 + w(i) * 1600/Pmax), 2

Next x

End If

Next i

For i = 1 To ns

If w1(i) >= 0 Then

For x = ass(i) To bs(i) Step 0.05

w11 = (w2(i) - w1(i))/(bs(i) - ass(i)) * (x - ass(i)) * (x - ass(i)) + w1(i)

Line (1320 + x * 7200/L, 2040)-(1320 + x * 7200/L, 2040 - w11 * 1600/Pmax), 8

Line (1320 + x * 7200/L, 2040)-(1400 + x * 7200/L, 1900), 2

Line (1320 + x * 7200/L, 2040)-(1400 + x * 7200/L - 150, 1900), 2

Next x

Else

For x = ass(i) To bs(i) Step 0.05

w11 = (w2(i) - w1(i))/(bs(i) - ass(i)) * (x - ass(i)) * (x - ass(i)) + w1(i)

Line (1320 + x * 7200/L, 2040)-(1320 + x * 7200/L, 2040 + w11 * 1600/Pmax), 8

Line (1320 + x * 7200/L, 2040 + w11 * 1600/Pmax)-(1240 + x * 7200/L, 2140 + w11 * 1600/Pmax), 2

Line (1320 + x * 7200/L, 2040 + w11 * 1600/Pmax)-(1400 + x * 7200/L, 2140 + w11 * 1600/Pmax), 2

Next x

End If

Next i

End Sub

Private Sub Command3_Click()

Cls

Label4.Caption = "Bending Moment Diagram"

'###Entering Data to Draw Bending Moment Diagram###

```
For kk = 0 To 20
For ff = 0 To 7200 Step 50
PSet (1320 + ff, 3340 + kk * 180),2
Next ff
Next kk
For kk =0 To 40
For ff = 0 To 3600 Step 50
PSet(1320 + kk * 180, 3340 + ff), 2
Next ff
Next kk
Fa = Int(4/L* 500)
PSet(1320, 5160), 2
j = -1
If Mmax = 0 Then Mmax = 1
For k = 0 To ne
x = k * h * Fa
j = j + 1
xx = 1320 + 7180 * (x/Fa)/L
Line -(xx, 5160 – 1800 * MB(j)/Mmax), 2
Next k
Mmax = Int(Mmax * 1000)/1000
For i = 0 To 4
Label3(i).Caption = Int(Mmax * (10 – 5 * i) * 1000)/10000
Next i
For i = 1 To np
If P(i) >=0 Then
Line (1320 + ap(i) * 7200/L, 2040)-(1320 + ap(i) * 7200/L, 2040 – p(i) * 1600/Pmax), 8
Line (1320 + ap(i) * 7200/L, 2040)-(1400 + ap(i) * 7200/L, 1900), 2
Line (1320 + ap(i) * 7200/L, 2040)-(1400 + ap(i) * 7200/L – 150, 1900), 2
```

Else

Line (1320 + ap(i) * 7200/L, 2040)-(1320 + ap(i) * 7200/L, 2040 + p(i) * 1600/Pmax), 8

Line (1320 + ap(i) * 7200/L, 2040 + P(i) * 1600/Pmax)-(1240 + ap(i) * 7200/L, 2140 + p(i) * 1600/Pmax), 2

Line (1320 + ap(i) * 7200/L, 2040 + P(i) * 1600/Pmax)-(1400 + ap(i) * 7200/L, 2140 + p(i) * 1600/Pmax), 2

End If

Next i

For i =1 To n

If w(i) >=0 Then

For x = a(i) To b(i) Step 0.05

Line (1320 + x * 7200/L, 2040)-(1320 + x * 7200/L, 2040 – w(i) * 1600/Pmax), 8

Line (1320 + x * 7200/L, 2040)-(1400 + x * 7200/L, 1900), 2

Line (1320 + x * 7200/L, 2040)-(1400 + x * 7200/L – 150, 1900), 2

Next x

Else

For x = a(i) To b(i) Step 0.05

Line (1320 + x * 7200/L, 2040)-(1320 + x * 7200/L, 2040 + w(i) * 1600/Pmax), 8

Line (1320 + x * 7200/L, 2040 + w(i) * 1600/Pmax)-(1240 + x * 7200/L, 2140 + w(i) * 1600/Pmax), 2

Line (1320 + x * 7200/L, 2040 + w(i) * 1600/Pmax)-(1400 + x * 7200/L, 2140 + w(i) * 1600/Pmax), 2

Next x

End If

Next i

For i = 1 To ns

If w1(i) >=0 Then

For x = ass(i) To bs(i) Step 0.05

w11 = (w2(i) – w1(i))/(bs(i) – ass(i)) * (x – ass(i)) * (x – ass(i)) + w1(i)

Line $(1320 + x * 7200/L, 2040) - (1320 + x * 7200/L, 2040 - w_{11} * 1600/P_{max}), 8$

Line $(1320 + x * 7200/L, 2040) - (1400 + x * 7200/L, 1900), 2$

Line $(1320 + x * 7200/L, 2040) - (1400 + x * 7200/L - 150, 1900), 2$

Next x

Else

For x = ass(i) To bs(i) Step 0.05

$w_{11} = (w_2(i) - w_1(i)) / (bs(i) - ass(i)) * (x - ass(i)) + w_1(i)$

Line $(1320 + x * 7200/L, 2040) - (1320 + x * 7200/L, 2040 + w_{11} * 1600/P_{max}), 8$

Line $(1320 + x * 7200/L, 2040 + w_{11} * 1600/P_{max}) - (1240 + x * 7200/L, 2140 + w_{11} * 1600/P_{max}), 2$

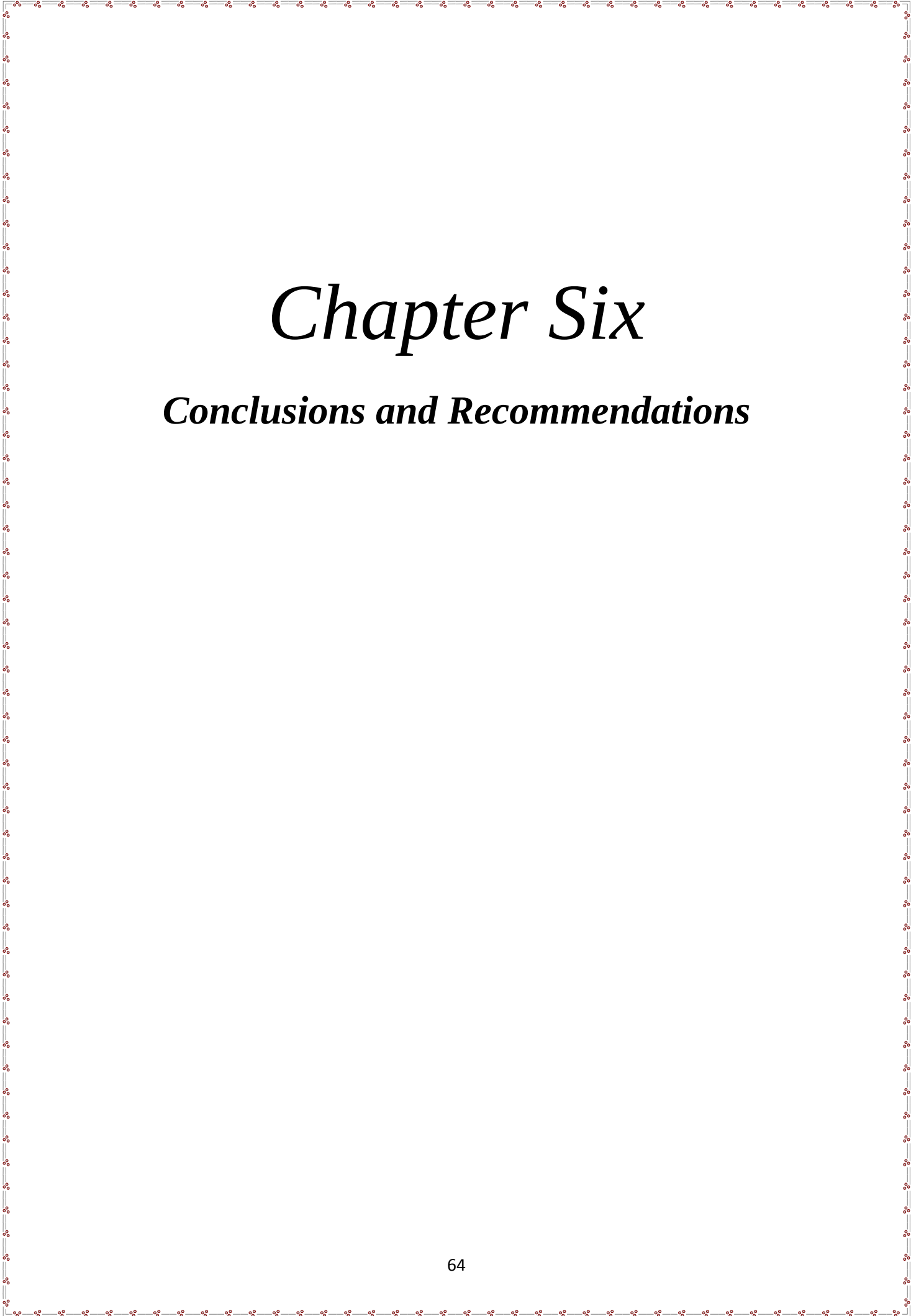
Line $(1320 + x * 7200/L, 2040 + w_{11} * 1600/P_{max}) - (1400 + x * 7200/L, 2140 + w_{11} * 1600/P_{max}), 2$

Next x

End If

Next i

End Sub



Chapter Six

Conclusions and Recommendations

Conclusions

Through the run of this program in this project on several beams, we had been concluded following :-

- 1-the program can draw the shear force and bending moment diagrams with the greatest value of both them.
- 2- The program is easy to run to get results without having to know the basic of theory.
3. The program reduces a lot of time and effort, it's only moments until you get all the solutions and results.

Recommendations

This program has dealt with the simply supported beams and it is therefore recommended that this programme be developed and expanded to include the following cases :-.

1. the continuous beam and other types of frame analysis
2. Write a program in another language better with the addition of some features that make the program easier explained
3. Develop the program to design the beams by finding the longitudinal and transverse steel area

	<i>References</i>
--	-------------------

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- 4- Pattison, Ted, and Don Box. *Programming distributed applications with COM+ and Microsoft Visual Basic 6.0*. Microsoft Press, 2000.
- 5- Verma, Mahendra P. "Steam tables for pure water as an ActiveX component in Visual Basic 6.0." *Computers & Geosciences* 29, no. 9 (2003): 1155-1163.



**MUSTANSIRIYAH
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CIVIL ENGINEERING
DEPARTMENT**

Planning and Design Requirement to Improve the Urban Climate in Arid Zones

Supervised By:

Dr. SUAAD RIDHA

Done By:

Faisal Hammoud Eabd

Fourth Stage -c-

2019 - 2020

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

هُوَ الَّذِي أَنْزَلَ عَلَيْكَ الْكِتَابَ مِنْهُ آيَاتٌ مُحْكَمَاتٌ هُنَّ أُمُّ الْكِتَابِ
وَأُخَرُ مُتَشَابِهَاتٌ طُ فَأَمَّا الَّذِينَ فِي قُلُوبِهِمْ زَيْغٌ فَيَتَّبِعُونَ مَا تَشَبَهَ مِنْهُ
ابْتِغَاءَ الْفِتْنَةِ وَابْتِغَاءَ تَأْوِيلِهِ ۚ وَمَا يَعْلَمُ تَأْوِيلَهُ إِلَّا اللَّهُ وَالرَّاسِخُونَ
فِي الْعِلْمِ يَقُولُونَ ءَامَنَّا بِهِ ۚ كُلٌّ مِّنْ عِندِ رَبِّنَا وَمَا يَذَّكَّرُ إِلَّا أُولُو
الْأَلْبَابِ ﴿٧﴾

صَدَقَ اللَّهُ الْعَظِيمُ

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Preface

This project is the fruit of my studying at the civil engineering department at Mustansiriyah University over the past four years. A great thank to my supervisor Suaad Ridha for giving me the opportunity to take part in this project and guiding me through the research work. Thanks to the staff of the civil engineering department. Grateful thanks are presented to My fiancée Ghofran for her assistance, supporting and encouragement through the preparation of this work.

Last but not least I would like to thank my friends, fellow students and parents for their moral support.

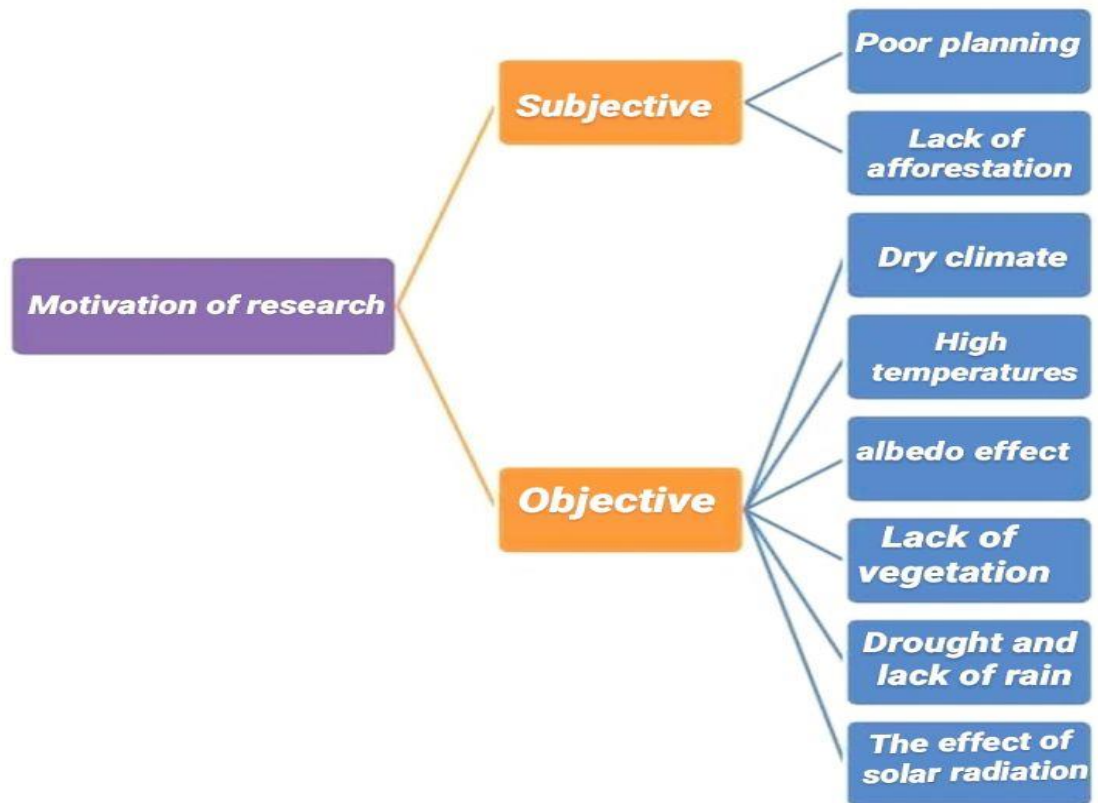
Faisal Hammoud

August 2020

Abstract

In light of the high temperatures and the drought the recent times, especially in the Arab world and Iraq, the problem of lack of thermal comfort has emerged, especially in the summer. In this project, the dry climate and its problems have been studied in Iraq, and we have also discussed the urban heat island and how the temperature in cities is higher than the temperature In the countryside and how to reduce urban heat island by water and plants. Also, we studied the effect of wind direction and orientation of buildings in relation to sunlight and spacing between buildings and their effect on increasing thermal comfort. At the end of the project three models were taken in three cities and a study of how thermal comfort was increased in these dry climates and finally We wrote some recommendations for a little bit of this problem .

Motivation of research



Chapter one

Definitions of Arid - Hot Climate



Chapter one

Definitions of Arid - Hot Climate

1. 1Introduction

Arid climates can be found on every continent. They range from hot and deserts that see almost no rain to semiarid scrub land where rain falls intermittently. Arid climates are not suitable for most life forms. Plants and animals that make their homes in arid climates have made special adaptations to the environment.

The defining characteristic of an arid climate is a lack of moisture. The soil is dry, the air is dry, and yearly precipitation is very low. A variety of factors combine to steer storms and moisture away from arid regions. In some arid climates, evaporation rates exceed precipitation, leading to a net moisture loss. In the hottest of arid climates, rain may evaporate before it can reach the ground. On the other hand, a torrential downpour may bring a short burst of life.

1.2 Some important definition about climate

1.1.2 Hot and Cold

Arid climates such as the Sahara Desert can be hot all year round with no noticeable seasons. Or they can have hot summers and frigid winters, like the Gobi Desert in Tibet. The Gobi experiences winter temperatures well below freezing. Even the hottest deserts typically have cold nights, because there's little vegetation to retain the day's heat. A travel exposed to a harsh, arid climate can suffer heatstroke during the day and hypothermia at night.

1.2.2 Rain Shadows

The leeward or downwind slopes of high mountains are often home to arid climates. When mountains receive the moisture from incoming storm systems, precipitation is abundant on the windward side, leaving the leeward slopes dry. The Gobi Desert in Tibet is a prime example of this phenomenon. The massive peaks of the Himalayas force moisture from the rising air. From the Gobi Plateau, you can see beautiful snow-capped peaks but rarely does rain fall.

1.2.3 Locations

Most of the world's arid climates lie just north and south of the tropical rain forests of the equator. Mountain plateaus are another location where you might find an arid climate. The southwestern corner of the United States, for example, is quite dry and hot. While not technically a desert the continent of Antarctica qualifies as arid. Very little precipitation falls so far south, and all of the region's moisture is locked up in snow and ice.

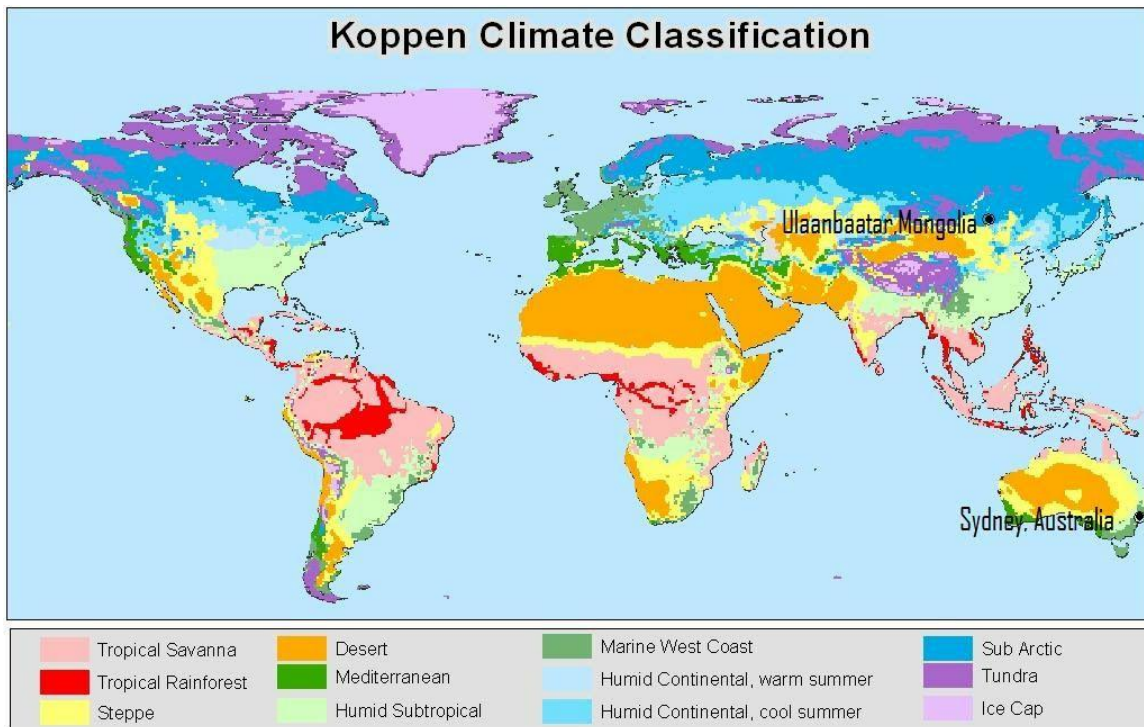


Fig (1-1) main climate zone

1.2.4 Rainfall in Deserts

Deserts are some of the most inhospitable places on earth. They are very dry, have very poor soil, and can experience wildly varying temperature extremes. The Atacama desert in the Andes mountains of South America is so dry it experiences less than 6 .01 cm of rain per year on average, and some areas can go years without any rain at all. Yet even these arid places have some water and will support some life.

1.2.5 Frequency of Rain

Most deserts get what little precipitation they do receive in a few, heavy rainfalls, rather than many light show ers of rain spread out over the year.

This leads to seasonal lakes and rivers which may last a few months, or even only a few days. Dry river beds are a common sight in many deserts and are called wadis in some African and Middle Eastern deserts. Some rainfalls may bring torrents of 5 to 10 cm of rain in a few hours, leading to flash flooding in ravines or canyons, a seemingly paradoxical occurrence in the driest places on Earth. Arctic and Antarctic deserts receive their precipitation almost entirely as snow.



Fig (1-2) (the deserts)

1.2.6 Humidity in Deserts

Deserts cover 20 per cent of the earth's surface yet are the driest regions in the world. Their lack of humidity is particularly striking because hot areas can hold so much moisture. Rainforests, for instance, combine warm air and high precipitation to produce some of the highest areas of humidity in the world. Deserts, on the other hand, are very dry, so they're antithetical to most life.

1.2.7 Solar Radiation

The scant desert humidity that exists in the air is unable to block the sun's rays, so the amount of solar radiation that deserts receive can reach twice the amount of humid regions. The daily temperature swings that follow can be extreme. On one end of the spectrum temperatures can reach up to 49 degrees Celsius (120 degrees Fahrenheit), and it's not unusual that it can occasionally drop below freezing.

1.3 What Climate Is Landlocked and Gets Little Precipitation?

Because most deserts lie in the interior of continents, they don't have water to moderate their temperatures. These landlocked climates tend to have little precipitation and great extremes in temperature. Daytime temperatures are often high, and at night, temperatures in some deserts dip to teeth-chattering lows. Because of its unique combination of conditions, only certain organisms with special adaptations can survive in such inhospitable areas.

1.4 Precipitation

Deserts receive less than 50 centimeters (19.7 inches) of rain per year. The Atacama Desert of Chile receives the least rainfall of all modern-day deserts,

averaging a mere 1.5 centimeters (0.6 inches) of rain per year. In general, deserts in the United States have the most precipitation per year of all the world's deserts, averaging about 28 centimeters (11 inches) of rain a year. Some inland deserts form because of rain shadowing, which may be why these deserts don't see rain often. Moist air rises over mountain ranges, and rain falls on the windward, or near, sides and tops of the mountains. This depletes the moisture so that when the air mass crosses the mountains and descends into the land beyond, no precipitation falls on the leeward, or far, side of the mountains.

1.5 Hot Deserts

The typical hot deserts with which you may be familiar include the Sahara in Africa, the Atacama in Chile and the Mojave in the United States. Deserts generally lie at the extremes of temperature ranges. At the higher end of the spectrum, deserts temperatures can soar to a scorching 49 degrees Celsius (120 degrees Fahrenheit) with mean annual temperatures in the 20 to 25 degrees Celsius (68 to 77 degrees Fahrenheit) range. At the lower end, deserts can dip to a frigid -18 degrees Celsius (-0.4 degrees Fahrenheit). Deserts in the northern United States, Europe, and northern Asia, however, have more moderate climates, with daytime summer temperatures ranging between 21 and 27 degrees Celsius (70 to 80 degrees Fahrenheit) and nighttime

temperatures hovering around 10 degrees Celsius (50 degrees Fahrenheit).



Fig (1-3) Hot Deserts

Climate change in the Arab countries There is a widely-held scientific conviction that the global climate is changing as a result of the combined anthropogenic forcing due to greenhouse gases, aerosols, and land surface changes. Many pieces of evidence have concluded with a high degree of probability that human activities have exerted a substantial net warming influence on climate since 1750 (IPCC, 2007b). Recent climatological studies found that the global surface air temperature increased from 1850 to 2005 by 0.76°C . Moreover, the linear warming trend over the last 50 years is recorded by 0.13°C per decade (IPCC, 2007b). Furthermore, there has been an increase

in the number of heat waves, a reduction in the frequency and duration of frosts, and an increase in extreme events frequency and intensity in many parts of the world. Regarding these global trends, the recent studies found that the Arab region experienced an uneven increase in surface air temperature ranging from 0.2 to 2.0°C that occurred from 1970 to 2004 (IPCC, 2007a). For the next two decades, a warming of about 0.2°C per decade is projected for a range of IPCC SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at the year 2000 levels further warming of about 0.1°C per decade would be expected (IPCC, 2007b).



Fig (1-4) the arabian desert

Physical and biological ecosystems on all continents and in most oceans have already been affected by recent climate changes (IPCC,

2007a). It is now generally accepted that this climate change is the result of increasing concentrations of carbon dioxide, methane, nitrous oxide and other greenhouse gases (GHGs) in the atmosphere (IPCC, 2001a). For the year 2000, the statistics showed that the world total GHGs emissions from all resources

were about 33 thousand Tg (teragram) (Figure 1-4), with Arab countries contributing about 4.2% of these total world emissions (WRI, 2005). As presented in Figure 2, the Kingdom of Saudi Arabia (KSA) is contributing the highest percentage of the total GHGs emissions from the Arab countries, followed by Egypt and Algeria (WRI, 2005). This relatively small contribution of GHGs of all

Arab countries do not correspond to the projected impacts of climate change over the region. The Middle East and North Africa region is a vast zone of generally diverse climatic conditions, characterized by very low and highly variable annual rainfall and a high degree of aridity (FAO, 2002b). As shown in Figure 3, most of the Arab region lands are classified as hyper-arid, semi-arid and arid land zones (WRI, 2002). Most recent assessments have concluded that arid and semi

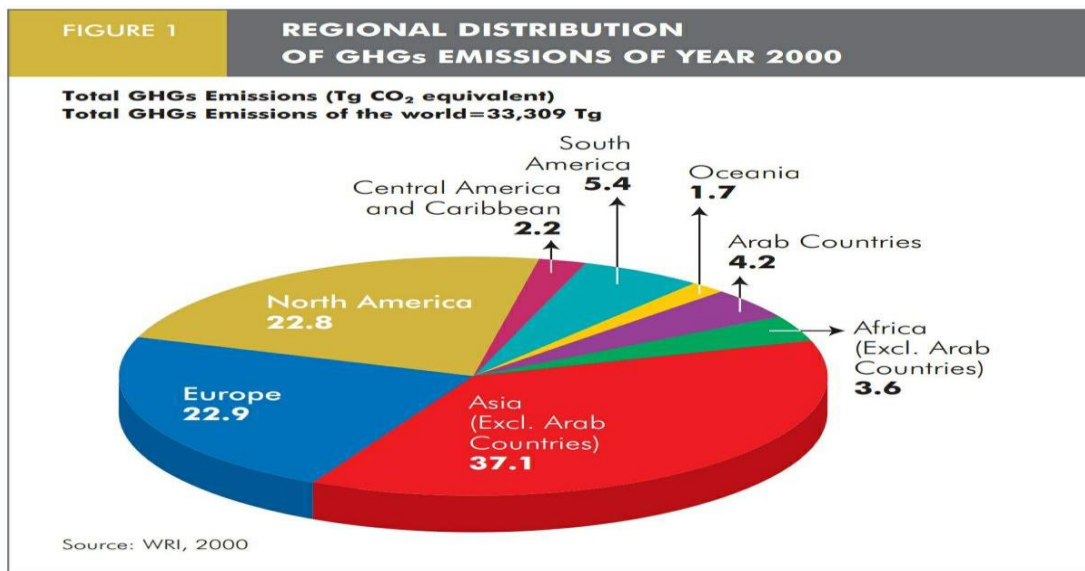


Fig (1-5) regional distribution of emission Of year 2000

arid regions are highly vulnerable to climate change (IPCC, 2007a; see also Chapter 7). Generally, the Arab countries are considered as developing countries and are highly vulnerable to

climate change impacts due to their arid climates. If temperatures in the region get higher, or precipitation gets lower, pressure on natural and physical systems would be intensified. According to modelling studies, the Arab region will face an increase of 2°C to 5.5°C in the surface temperature by the end of the 21st century. This increase will be coupled with a projected decrease in precipitation from 0 to 20%. These projected changes will lead to shorter winters, dryer and hotter summers, a higher rate of heat waves, a higher level of weather variability and a more frequent occurrence of extreme weather events. The purpose of this chapter is to give a general overview of the studied impacts of the projected climatic changes in the Arab region, to address some key points in the way of adaptation and mitigation planning.

1.8 mm per year through the period of 1961- 2003; it should be noted that the observed rate over 1993 to 2003 was markedly higher, at about 3.1 mm per year. The total 20th- century rise is estimated to be 0.17 m (IPCC, 2007b). The available scientific evidence has found that the continued growth of GHG emissions and associated global warming could lead to SLR of 1 to 3m in the 21st century, and an unexpectedly rapid breakup of the Greenland and West Antarctic ice sheets might produce a 5m SLR (IPCC, 2001b). However, there are uncertainties in the estimates of SLR in the longer run (IPCC, 2007b). The nature of the impacts of sea -level rise will vary from place-to-place and country-to-country. This is due to a variety of factors, depending on local conditions such as elevation of the land and currently occurring geological land subsidence, reflecting that certain settings are more vulner able.

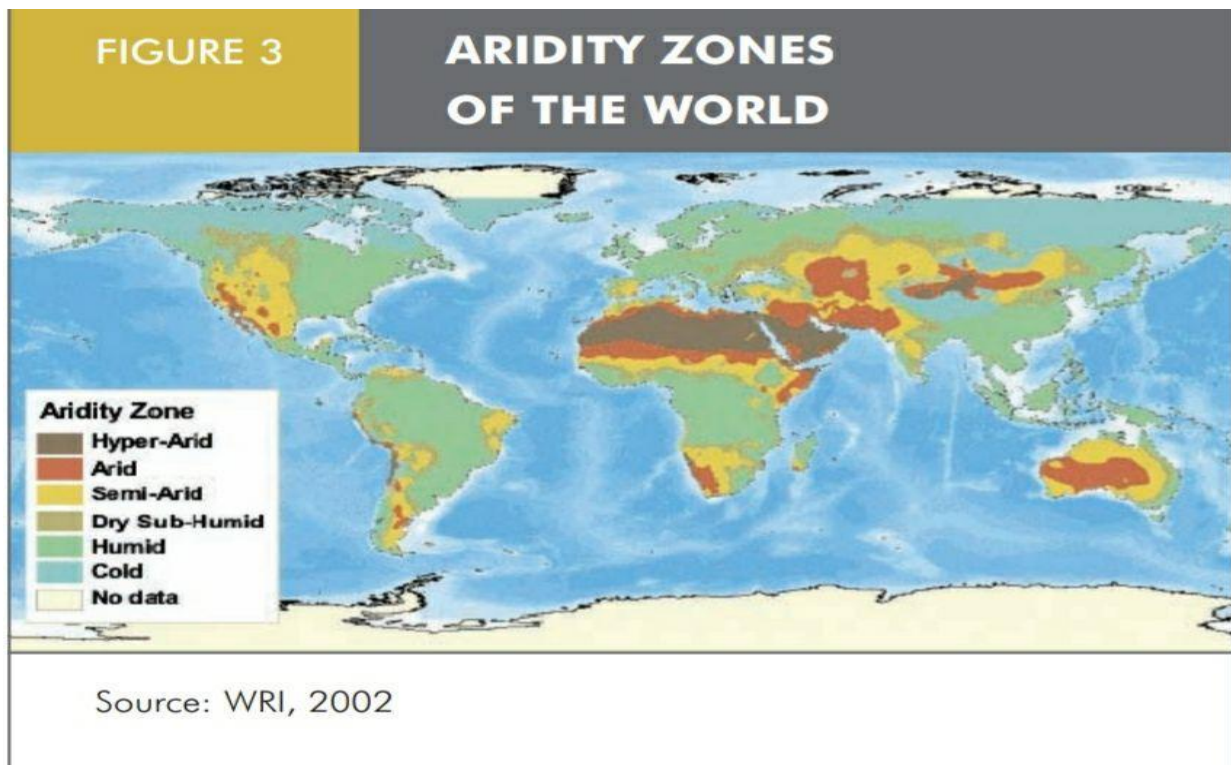


Fig (1-6) aridity zones of the world

1.6 Climate in Iraq

The main factor that affects the climate of Iraq is its astronomical location, that is, the location concerning the circles of latitude because it determines the angle of sunlight fall and the length of the day, that is, the period during which the sun shines. Orbital resemblance as well, this site affects the type of prevailing winds blowing on it. This location made it blew in the west winds in the winter. The second factor is its proximity to water bodies, where it is noted that the water areas that affect the climate of Iraq is the Arabian Gulf and the Arabian Sea and is located at the extreme edge of the southeast, and the Mediterranean Sea is located to the west of it at a distance of more than

1000 km. The third factor affecting the climate of Iraq is the height of the mountains and the shape of their extension, as they have an effective role in northern Iraq in particular because of their altitude there as they adjust the intensity of the temperatures and increase the amount of precipitation and the shape of the terrain in the countries surrounding Iraq also affects a clear impact in determining the quality of its climate as it constitutes the factor The main paths for air mass paths, wind gusts, and directions with varying pressures (high or low).

1.7 Iraqi climate characteristics

The climate of Iraq is described as semi-tropical in terms of temperature because 4-11 months having an average in excess of 20 ° C (68 ° F), which is the rule established by the world in terms of climate classification. It is also a continental climate to match the climate of Iraq with the four characteristics that characterize the continental climate, namely- : A- The daily and annual temperature range is high B- Palace of Transitional Seasons (Spring and Autumn) C - lack of rain D - Low relative humidity The climate of Iraq is also characterized by most of the daily and annual thermal range due to the lack of wide water bodies that reduce the coldest winter and the summer heat. In Mosul, the average temperature in January is 11.9 ° C and in July 33.4 ° C, thus the range is 25.5 ° C, in Baghdad 24 and Basra 22.2 M. The range in the southern sections is lessened by the influence of the Arabian Gulf, especially in the winter, where the wet wind comes from the aforementioned Gulf. In the summer, the influence of the Gulf is not felt because the wind comes from the northwest.

And the extent of the daily heat is important from a health point of view, as it compensates for the extreme summer heat by decreasing the temperature of the night and its mildness, which makes Iraq's summer more likely than India's seasonal summer. The daily range of the July heat increases with an increase in the circle of latitude, that is to the north, due to the lack of clouds in the sky and the lack of relative humidity in the air, which helps in the speed of the loss of the earth's temperature at night, while the daily range decreases a lot in January due to the increase in relative humidity and a large number of clouds. The low temperature of the night is attributed to the rapid loss of daytime heat after sunset, as the clear sky moves that process of loss from the surface of the earth. The same phenomenon in mountainous regions is also attributed to the state of air behavior or as it is called the cold mountain breeze that blows from the highlands to the valleys. As for the second continental characteristic, it is the shorter transmission seasons (spring and autumn), and this is what happens in the countries far from the seas.

Spring is clearly in the steppe region, where the lands are covered with many flowering plants and green weeds, and these plants remain in a dormant role in the hot summer, but in the nights of spring, they are cold, where the climate is pleasant for those coming to it from the south with little rain, and only short scattered weeds grow. The third continental characteristic is the lack of rain in the direction from the northeast to the southwest. In the mountainous regions, the rains reach 400-1000 mm, and in the steppe 200-400 mm and the northern deserts 200 mm and decrease to less than 50 mm in the southwestern desert. The climate of the mountainous region can be considered a climate the Mediterranean Sea due to its heavy rains, however, its temperature is few in

the summer because of its height. Its winters are bitter and accordingly, the heat does not resemble the typical Mediterranean climate. The climate is in to Iraq. The fourth grade is the relative humidity, which ranges from 24.3% (in July) to 73.4% (in January) in the city of Baghdad during the period 1971-2000, where the annual average humidity is 49.3%.

The lack of relative humidity in central and northern Iraq causes a person to endure the high summer heat and is upset with it when he is in Basra because the lack of relative humidity in the middle and north helps or gives way to the sweat of the human body with evaporation. Man feels uncomfortable while feeling uncomfortable when the relative humidity rises and the sweat remains on his body as in Basra. In general, it can be said that the climate of Iraq is best described as a semi-tropical continental rain, similar to the Mediterranean climate system. The astronomical location of Iraq and its distance from the seas have made its climate characterized by continentality and it is located within the hot tropical region in its southern half and within the moderate greenhouse region in its northern hemisphere. It follows that the sun rays are vertical or near vertical or close to vertical during summer and inclined or near oblique during the season Winter and daytime are longer during summer than in winter months, with an increase of three hours and 48 minutes. Another term is the length of daylight in July, the hottest months of the year are 14 hours and 4 minutes, while in the second month of Kanzen it reaches the coldest months of the year to 10 hours and 16 A minute. And the length of the period now Har, the sky of Iraq is characterized by its purity and free from clouds, and its air is characterized by a lack of air humidity, which helps the

largest amount of solar radiation to reach the surface of the earth, most of which are free of vegetation.

1.8 Design for hot – arid zone

The following are the main design objectives:

- Provide maximum shade in summer and adequate heat gain in winter.
- Minimize reflection (indirect solar radiation) in streets and open spaces.
- Moderate the effects of undesired winds.
- Plan narrow winding alleys and streets, which are shaded and relatively cool and break stormy winds, but allow through ventilation and adequate natural lighting.
- Design suitable building forms.
- Plan proximity of urban services and daily functions within walking distance; wide roads can thus be omitted or at least reduced.
- Avoid large open spaces within the city where hot air can collect during the day and which are conducive to duststorms.
- Provide ample shaded public spaces.
- Select light colors for every open space.
- Include green areas of plants around and within the settlement to provide shade and cool air and to stabilize the soil.

- Plant and cultivate xerophytes that require little or no water.
- Integrate water bodies, which evaporate and therefore reduce the temperature.

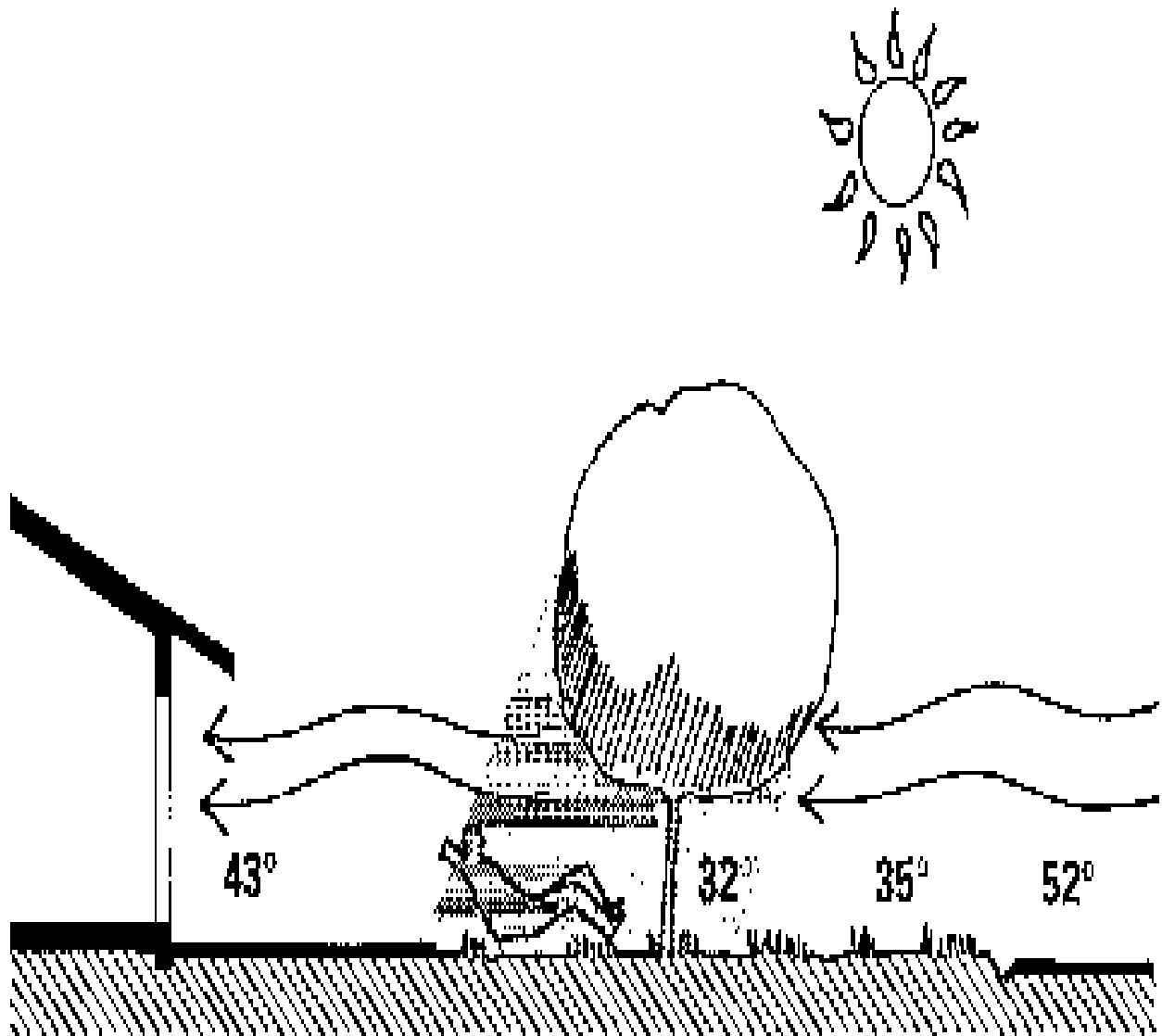
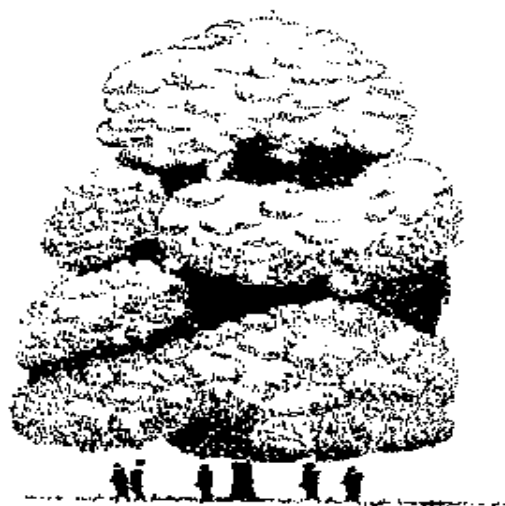


Fig (1-7) design for hot – arid zones



Millettia atropurpurea
Cooling Factor 28%



Delonix regia, Red Flame
Cooling Factor 14%



Enterolobium saman, Rain Tree
Cooling Factor 18.5%



Pterocarpus indicus, Angsana
Cooling Factor 26%



Roystonea regia, Royal Palm
Cooling Factor 2%

Fig (1-8) Selected trees and their "cooling factor"

Chapter Two

Urban heat island phenomenon



Chapter Two

Urban heat island phenomenon

2.1 Introduction

The global climate has changed due to the interaction between greenhouse gases, aerosols and air pollutants, as well as a human activity. It has had a major impact on the climate, as initial studies have compelled that the temperature may be 0.76 per cent from 1850 to 2005, as well as increased temperatures and are frosty.

Initial studies have found that the temperature may be uneven in Arab countries

Temperatures are expected to be warmer in the coming years.

The Arab region will face an increase in temperatures estimated from 2 to 5.5 ° C at the end of the 21st century. Increased temperatures are accompanied by a decrease in rainfall rates of 20%. These changes will lead to a shorter winter, higher droughts, and an increase in heat waves.

As a result of these reasons, we must take into account the requirements in designing cities in dry and hot areas such as the height of the buildings and the distances between them and direct the buildings to sunlight and direction of wind movement as well as green areas to increase the thermal comfort of the consumer.

2.2 UHI (Urban heat island)

It is one of the most important phenomena that have been observed in major cities, as buildings and paved roads absorb heat during the day and then release it during the night.

The spatial distribution of the degree of temperature is closely related to the intensity of land use. Only a few parts of the solar radiation reach the environment directly. The remaining part connects indirectly through the use of buildings and structures as shown in the figure (2-1).

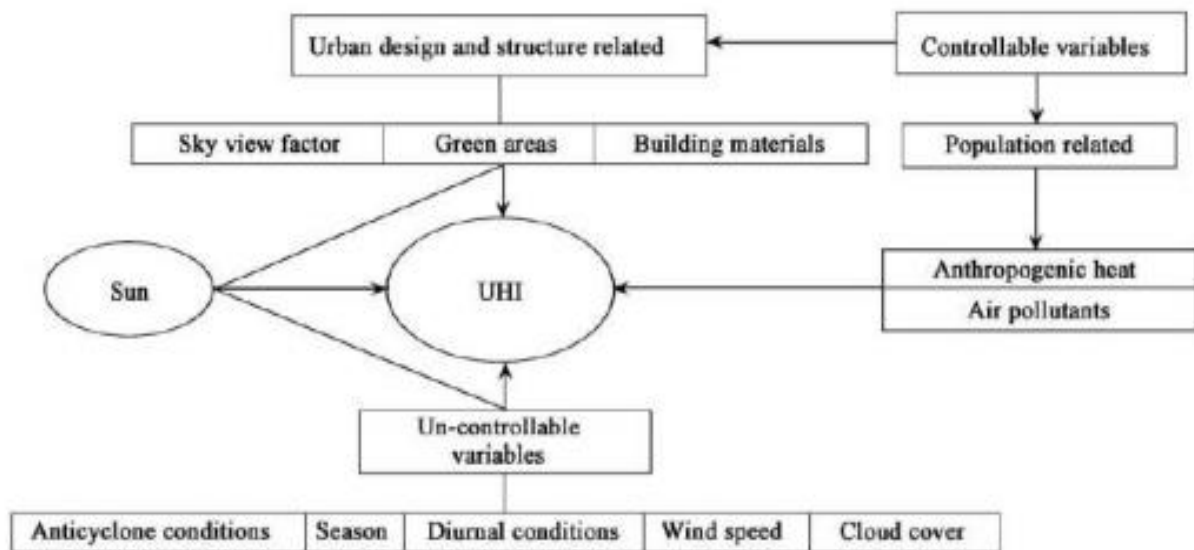


Figure 2-1 – Variables causing UHI (Memon et al., 2008)

The higher absorption of pure radiation by urban structures leads to a rise in surface temperature in urban areas. However, the stored net radiation is

released by the environmental zone structure as reasonable and latent heat flows. Consequently, urban structures will release more heat than their counterparts in rural areas.

The heat produced by human sources will also be converted to stored heat. Thus, the heat produced by human resources as well as from human sources will increase the air temperature. All heat fluxes can be combined in the following equation.

$$Q^* + QF + QH + QE + \Delta QS = 0$$

Where Q is the net radiation of all waves, and it can be described as the difference between the incoming short wave radiation and the existing wave. QF is a reasonable heat flow. QH heat emitted from built structures. ΔQS Heat stored inside the structures of the region. QA is the net thermal adherence from complex terrain and is negligible in the case of low density and weights are distributed horizontally uniformly.

2.3 Mitigating the UHI by vegetation

There are two ways in which vegetation can contribute to the mitigation of the UHI. The first is by providing shade, the second way is by evaporation. However, evaporation will only occur when the vegetation is provided with enough water. The city Phoenix estimates that approximately two - thirds of municipal water is used outdoors to maintain trees, shrubs, and grass and to compensate for pool evaporation. A study done in Phoenix shows that more irrigated vegetation produced more evaporation and less stored heat to be released at night. But efficiency declines as the wet fraction (share of the surface area devoted to irrigated vegetation) increases. A logistic model fits the data best, with the flattening slope indicating that adding water when the wet fraction is above 0.20, is an inefficient strategy for reducing temperatures. (See figure 2.1.) So, efforts to increase vegetative cover should concentrate on neighborhoods with the least vegetation, where substantial gains in cooling can be achieved with minimal additional water use.

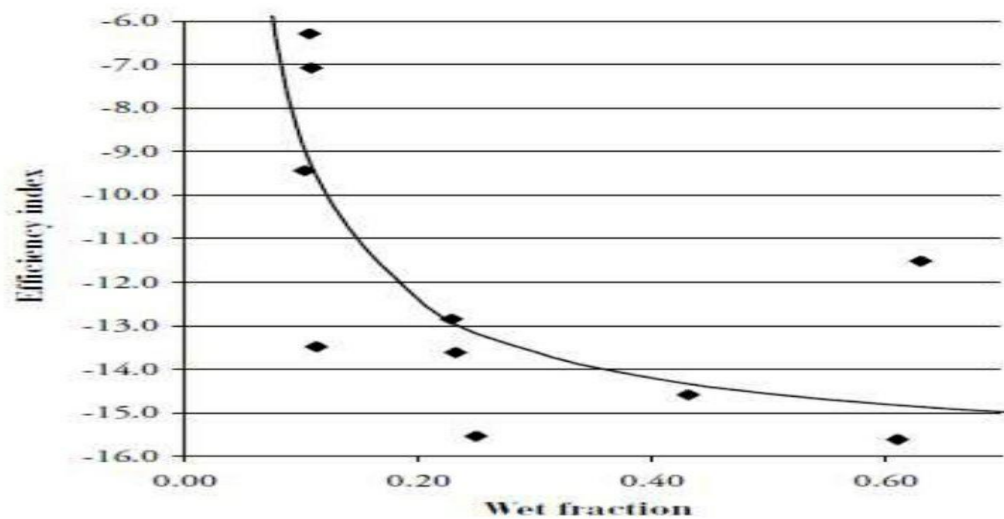


Figure 4. Nonlinear correspondence between declining efficiency index and increasing wet fraction.

Note:

The *efficiency index* is the amount of nighttime cooling per unit of evaporation. The *wet fraction* is the percentage of surface vegetation that is irrigated. $R^2 = 0.534$.

Fig (2-2) nonlinear correspondence between declining efficiency index and increasing wet fraction

Vegetation in cities can play an important role to adapt cities for climate change. Modeling work done in Manchester, England, suggests that the use of urban green space offers significant potential in moderating the increase in summer temperatures expected with climate change. Adding 10% green in high-density residential areas and town centers kept maximum surface temperatures at or below

1961–1990 baseline levels. Like as in most studies about vegetation, one caveat to the potential of green cover in moderating surface temperatures in

the case of a drought, when the grass dries out and loses its evaporative cooling function.

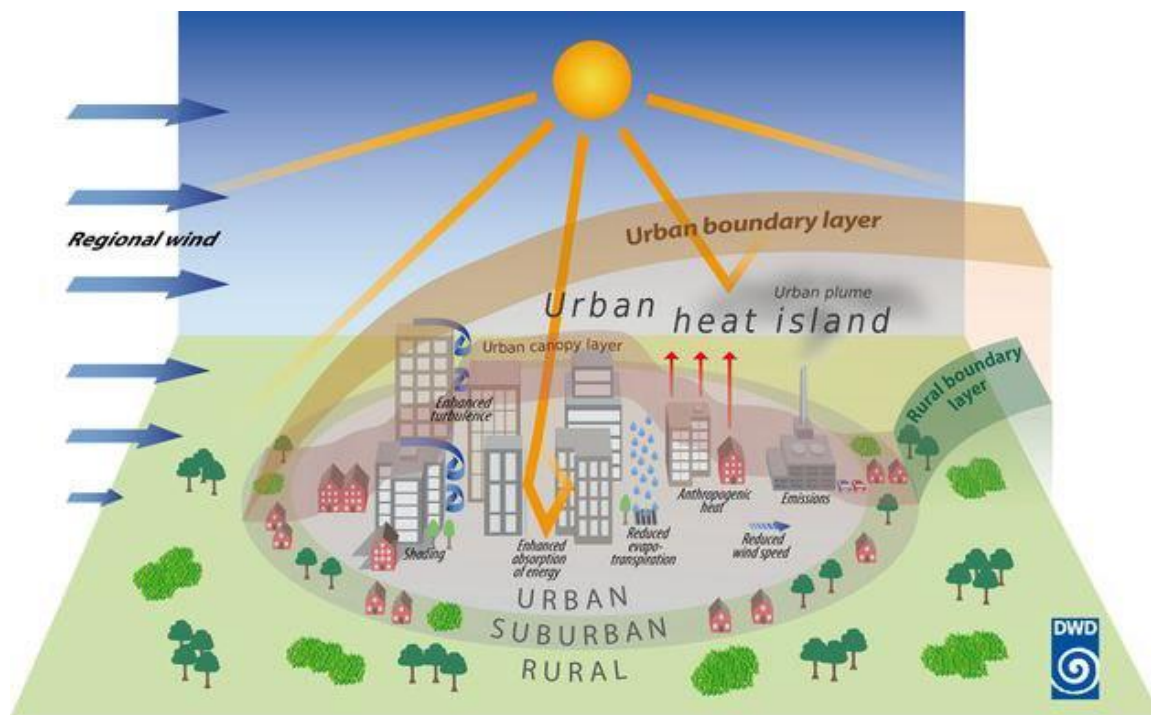


Fig (2-3) _ urban heat island

Vegetation plays a more important role than albedo or other features of the urban physical geography (e.g. building heights, road density) in determining heat island potential. Model results in New York City indicate that the most effective mitigation strategy per unit area redeveloped is curbside planting. The average difference in air temperature just above the surface, between impervious surfaces and trees was

1.9°C. This is higher than the differences between other surface-cover types. Therefore, street trees – which involve the redevelopment of impervious surfaces – have the largest cooling potential per unit area. (Columbia university center for climate systems research, 2006) A phenomenon within

the Urban Heat Islands is the Park Cool Island (PCI). It is the effect a park can have on temperature. Within a UHI, a park usually provides cooling resulting in a temperature decrease within a UHI. A study was done in Nagoya, Japan investigates the Park Cool Island, using a 90-m spatial resolution of ASTER LST data. The results of this study show that larger parks have stronger cooling effects. The maximal PCI intensity was 6.8°C and the average PCI was 1.3°C. Investigated parks were classified into nine different land-use types and it turned out that the intensity of PCI in Nagoya mainly is determined by areas of trees and shrubs in the park as well as the park's compactness.

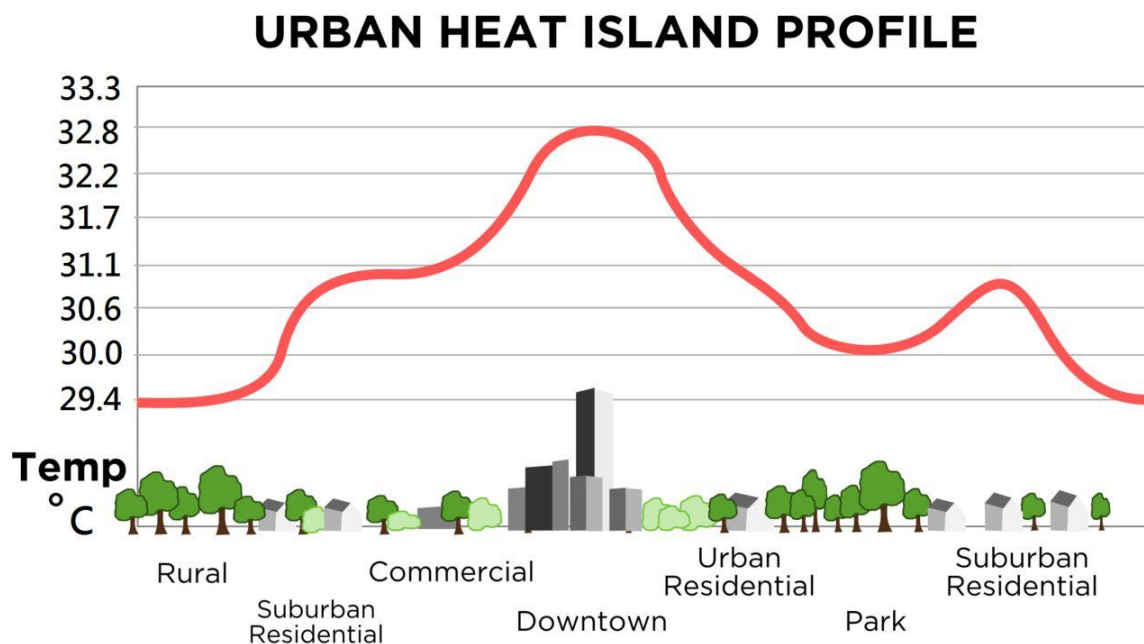


Fig (2-4) urban heat island profile

An Israeli paper considering different combinations of top and ground cover shows that the combination of shade trees over the grass was the most effective landscape strategy in terms of the cooling provided, with Tmax reduced by up to 2°C. Planting

grass gave 0.3°C cooling of the air above, yet consumed large amounts of water under Israeli conditions (5.71 kg/m² per day). Shading the grass, either by trees, had the effect of increasing the cooling effect to 0.5°C and reducing water consumption (3.81 kg/m² per day). Both trees and mesh have the potential to improve outdoor thermal comfort in areas where they provide shade. This is indicated by the fact that in both cases the surface temperature of the shaded ground was reduced substantially. Introducing grass under trees or under the mesh further reduces the ground temperature, thus contributing even more to thermal comfort. Trees provide by far the most efficient means of reducing outdoor air temperature, relative to their water consumption. A reduction of 1.1°C, and water consumption of 1.06 kg/m² per day.

There is also a negative part of trees in urban areas, which is caused by the fact that trees decrease the wind speed. The effect of trees and buildings on wind speed at points in a Chicago residential neighborhood over approximately one July week showed that wind speed was reduced by 83 to 85 percent on average compared to a location in the middle of O'Hare Airport, 6 miles to the west. The location where the wind speed reduction was measured, consists of 40% out of buildings and 10% is covered with trees crowns, so only a part of the wind speed reduction is caused by trees.



Fig (2-5) Negative effects of trees

Mitigating effects of trees and parks are not reduced to the location of these parks itself. There is also a cooling effect on its surrounding. It is found that the range of the cooling effect of parks was rather narrow and is perceivable up to 100 m from the site boundary. This fact corroborates earlier studies, although in this case, they are dealing, by design, with much smaller green areas not wider than 60 m. The cooling values were found to follow an exponential decay function. (Shashua-Bar and Hoffman, 2000) A different study out of Japan talks over an even smaller effect to the surroundings. The air temperature difference between the green area and the surrounding area for this study is about 2.5°C. Even small green areas indicated the cooling effect. But the area which has a cooling effect extends only about 20 m from the green area. The distribution of air temperatures corresponded to the

distributions of humidity and surface temperature. The cooling area moved with the wind direction.

2.4 Mitigating the UHI by water

It is believed that water plays an important role by mitigating the UHI, however, the effects are, to date, not easily measurable. Although there is generally an agreement on its positive impact on urban climate, the measurement and the quantification of these effects remain delicate and limited. One important reason for this situation is mainly the complexity of the phenomena concerned and the difficulty of obtaining rigorous and reliable physical models connecting the physical parameters of urban microclimate and the urban factors. (Robitu et al., 2003) One cubic meter of water evaporated consumes 2448 MJ. A reduction in evaporation means the increased conversion of short-wave global solar radiation to long-wave emissions and sensible heat. The amount of evaporation reduces significantly due to the global loss of forests, the increase in urbanization and further reduction of fertile agricultural areas. Reduction in evaporation causes higher surface temperatures (figure 2.6 & 2.7) (Schmidt M., 2005.)

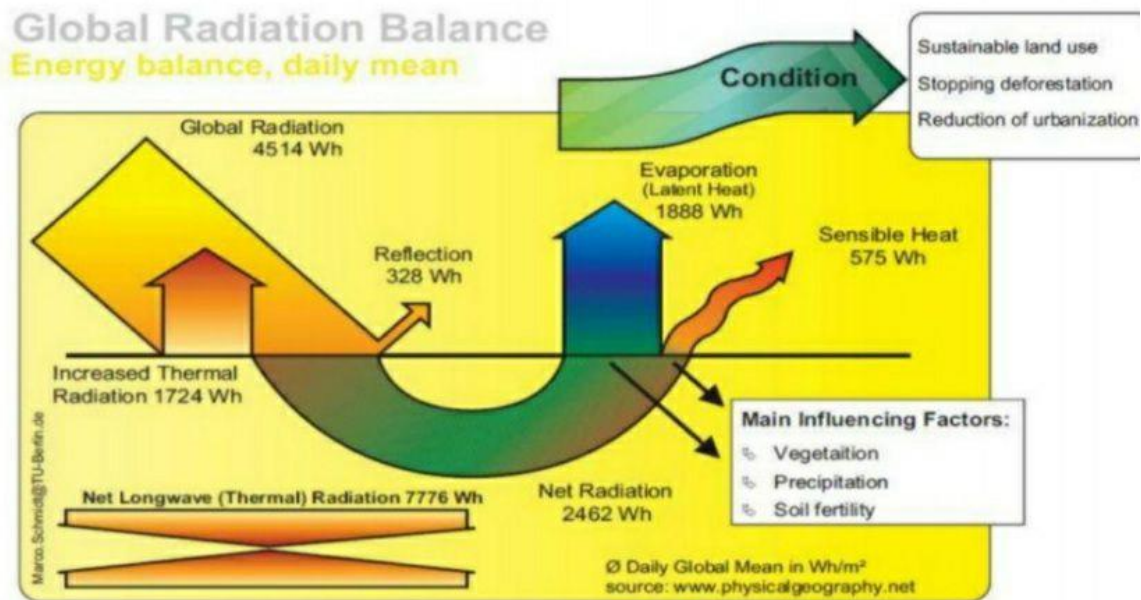


Fig (2-6) radiation balance (Schmidt m. 2005)

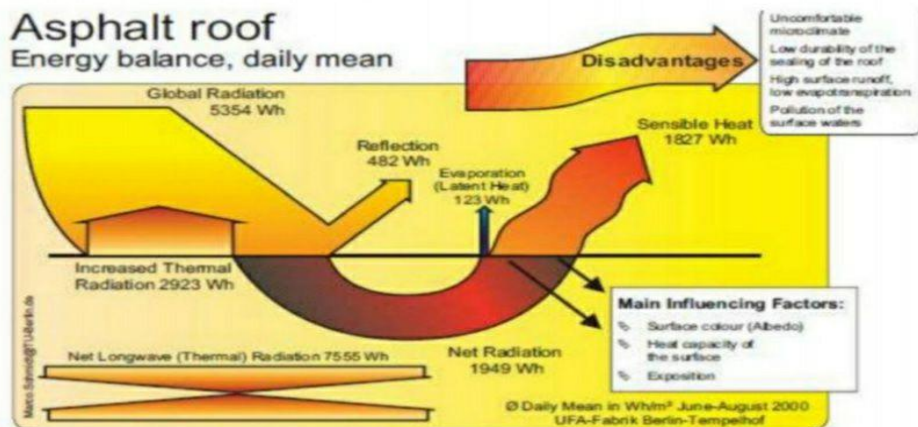


Fig (2-7) radiation balance for asphalt roof

An early study done in 1916 already indicates rising temperatures due to subsurface drainage in New Orleans. In the original situation of the city, all sewage water was discharged into wells, walled up and sealed over so that the water from the sewage was distributed through the soil. In 1903, an operation of sanitary sewers was commenced in the city. From 1903, no water flows in the open gutters on the streets anymore. Storm waters and the water

discharged daily into the sewer wells, to spread out through the soil and maintain a high ground water level, now go out through the drainage and sewerage systems. As a consequence, the ground water, instead of being level with the surface of the earth, is now 1.8 to 2.4 meter below that surface. On nearly all sides of New Orleans, large areas of marshland, which were covered the greater part of the year with tidewater, have been drained now. Comparison of the temperature 15 years before the installation of the subsurface drainage (1885-1899) to the temperature 15 years with subsurface drainage in operation (1900-1914), gives surprising results. Before 1900, the temperature had never reached 100° F and has been recorded 7 times in the period 1900-1914. Temperatures of 95° F or higher were recorded before 1900 on 35 days, while in the second period of 15 years temperatures of 95° F or above were recorded on 74 days. (Cline I.M., 1916) There is one study considering the effects of a water pond on mitigating the UHI.

This study was carried out in Osaka, Japan. An artificial water facility in a park in an urban area was used. The study focused on the pond (about 0.2 m deep) which combines a waterfall on the side of stone pillars and a spray fountain. Measurement points were set around the pond at the points b, c and d as can be seen in figure 2.8. The temperature over time for these three points can be seen in figure 2.9

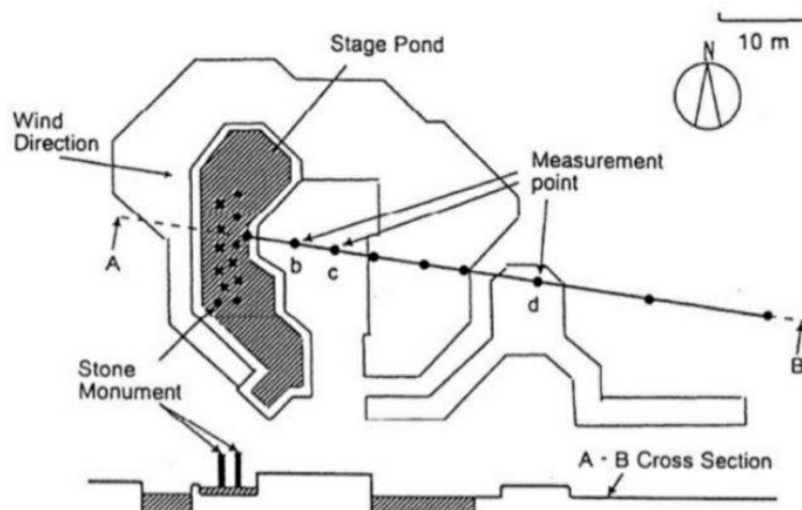


Figure 2.8 – Location of measurement points (Nishimura et al., 1998)

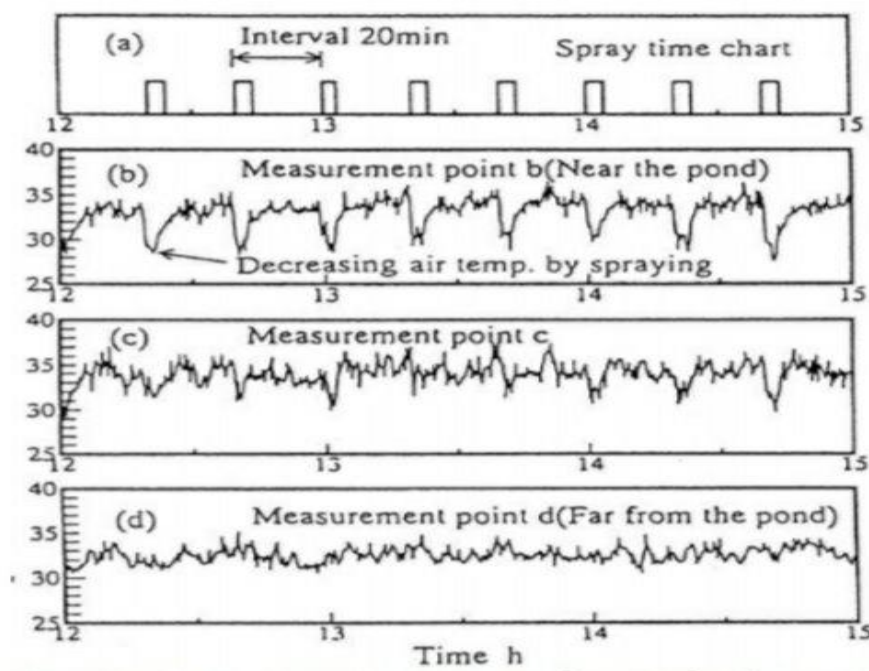


Figure 2.9 – temperature of point's b, c and d, corresponding to figure 2.9.

(Nishimura et al., 1998)

It can be observed from figure 2.5 that the closer the measuring points are to the stage pillars, the more the effect of temperature fall by the spray can be obtained. These degrees of temperature decline and fluctuation seemed to be affected by elements such as wind direction, velocity and turbulence. also, the surface temperature of different surfaces is recorded in this study. on the paved stone, the maximum ground surface temperature reaches above 50 degrees in the daytime, but the water temperature in the pond is around 30 degrees, and the maximum ground surface temperature on the wet paved stone by the spray fountain was about 39 degree. (Nishimura et al., 1998) In 2011, Deltares carried out some measurements in Rotterdam, to understand the effect of surface water on air temperature in the city. It turned out that the effects in the region just above the water surface to 50 cm above the water surface can be up to 6°C. However, the effects on street level are much smaller. Only the streets at which the water is located directly, profit from some decrease in temperature. But the effect on a street level could be underestimated, while the effects should be largest when it is about summer temperatures with no wind and because the effects on street level are measured at a height of 5 meter.

2.5 Albedo

is the measure of the diffuse reflection of solar radiation out of the total solar radiation and measured on a scale from 0, corresponding to a black body that absorbs all incident radiation, to 1, corresponding to a body that reflects all incident radiation. Surface albedo is defined as the ratio of radiosity to the irradiance (flux per unit area) received by a surface The proportion reflected is not only determined by properties of the surface itself, but also by the spectral

and angular distribution of solar radiation reaching the Earth's surface. These factors vary with atmospheric composition, geographic location and time. While bi-hemispherical reflectance is calculated for a single angle of incidence (i.e., for a given position of the Sun), albedo is the directional integration of reflectance over all solar angles in a given period. The temporal resolution may range from seconds (as obtained from flux measurements) to daily, monthly, or annual averages. Unless given for a specific wavelength (spectral albedo), albedo refers to the entire spectrum of solar radiation. Due to measurement constraints, it is often given for the spectrum in which most solar energy reaches the surface (between 0.3 and 3 μm). This spectrum includes visible light (0.4–0.7 μm), which explains why surfaces with a low albedo appear dark (e.g., trees absorb most radiation), whereas surfaces with a high albedo appear bright (e.g., snow reflects most radiation). Albedo is an important concept in climatology, astronomy, and environmental management (e.g., as part of the Leadership in Energy and Environmental Design (LEED) program for sustainable rating of buildings). The average albedo of the Earth from the upper atmosphere, its *planetary albedo*, is 30–35% because of cloud cover, but widely varies locally across the surface because of different geological and environmental features.

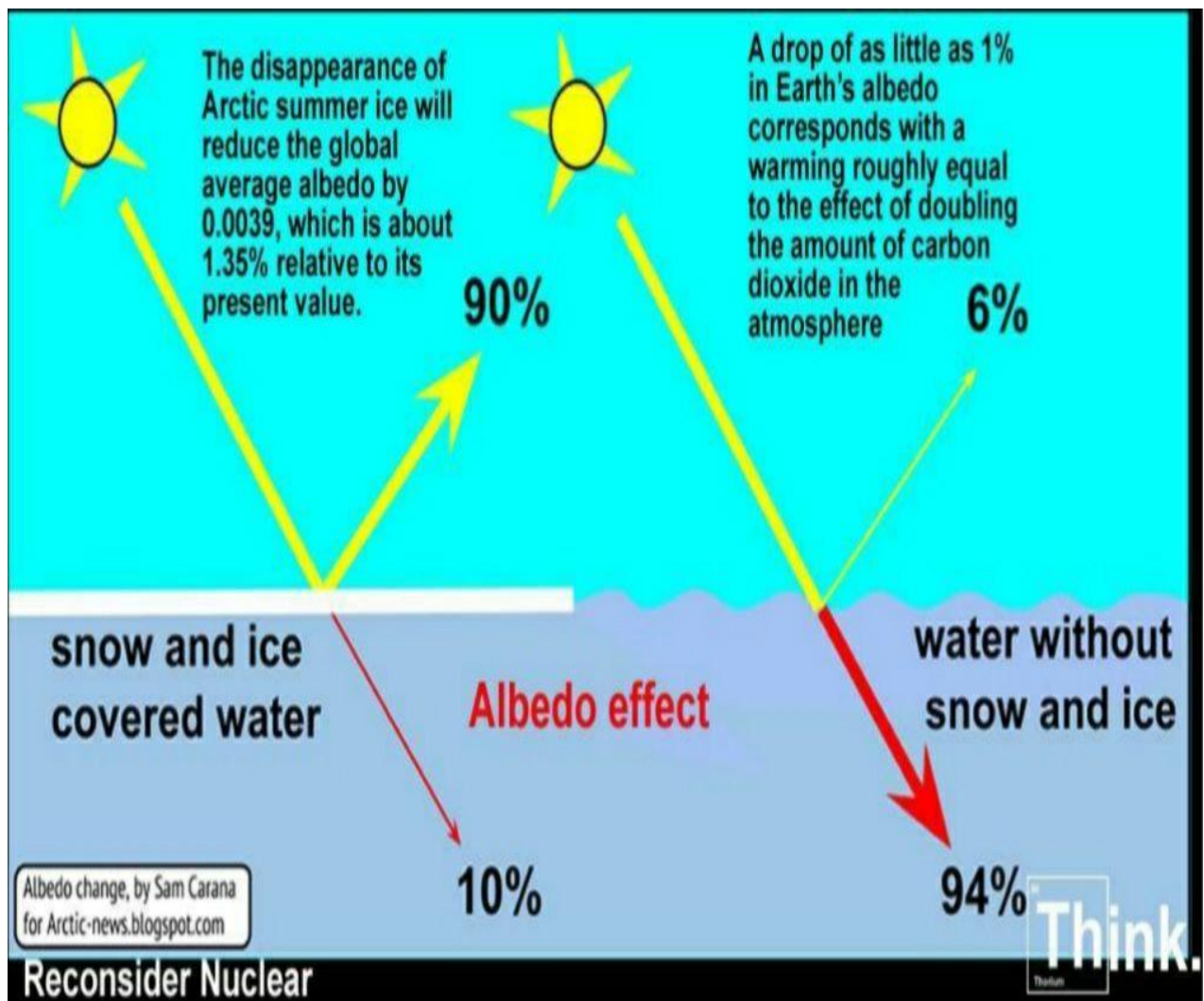


Fig (2-10) albedo effect

Chapter three

Design requirements for cities in hot climate



Chapter Three

Design requirements for cities in hot climate

3.1 Introduction

Confrontation the severe changes in the climate are a necessity that preoccupies engineers and designers, especially in arid regions. Most important of climate change which is the high temperatures and the danger of drought. Recently, the hot areas are not only threatened but the danger has been extended to even cold areas. The current attention is focused on how to create an enabling environment that can face climate challenges through understanding the requirements of planning and design to improve the urban climate. This chapter aims to highlight the most important requirements for urban planning and design in arid zones. Improving greenery strategies, reducing ground coverage which means reduce the frontage areas of building to allow air ventilation into the city and increase urban cooling, and enhancing buildings permeability for wind penetration and aspect ratio for urban ventilation. These planning design measures are determined based on the urban climate considerations for urban planning and design in arid zones. Recently, design cities in a hot, arid climate and sustaining an appropriate level of outdoor thermal comfort is one of the most significant challenges facing the designers. These challenges involve how to obtain a suitable climate for pedestrians during the day under the blazing sun, especially in

countries with an extreme rise in summer temperatures and for several months, as in Iraq.

3.2 Building Spacing

Building spacing is expressed in this paper with a ratio between building height (H) and street width (W) – aspect ratio (H/W). Street aspect ratios as a function of obstruction geometry affect short-wave and longwave radiative fluxes at the surfaces of urban canyons. Hourly solar radiation input to the canyon is greatly influenced by the extent to which the canyon surfaces are shaded during the day. Long-wave radiation loss from the canyon is affected by the obstruction of the canyon surfaces from the sky temperature sink. Therefore, the aspect ratio has a significant impact on air temperature variations. The impact of the aspect ratio on the temperature pattern comprises three interrelated but opposing effects. Deeper canyons increase both thermal inertia and shaded areas, but decrease the sky view factors of canyon walls. A decreasing sky view factor results in a roughly steady temperature increase over the course of the day [Ref.4]. Nevertheless, the increase of shaded areas causes a more noticeable temperature decline at the maxima than at any other time. The effect of aspect ratio on thermal inertia follows its relationship with building surface/volume ratio. Urban configurations of the same building density and different aspect ratios have different wall areas that affect building surface/volume ratio.

3.3 Influence of aspect ratio

According to an investigation carried out in the hot and arid city of Riyadh (Saudi Arabia) to evaluate the thermal performance of traditional and modern residential urban canyons, Fig. (3-1), the exposure of urban surfaces to the solar radiation is a function of the aspect ratio (H/W) and orientation of the canyon. They play a dominant role in determining the quantity of received solar radiation by the horizontal and vertical surfaces of the canyon and thus affect the ambient temperature inside the canyon. It was observed that the shallow modern canyons with $H/W = 0.42$ experience higher ambient temperatures during daytime when compared to the deep traditional aspect ratio $H/W=2.2$ (Bakarman and Chang, 2015).

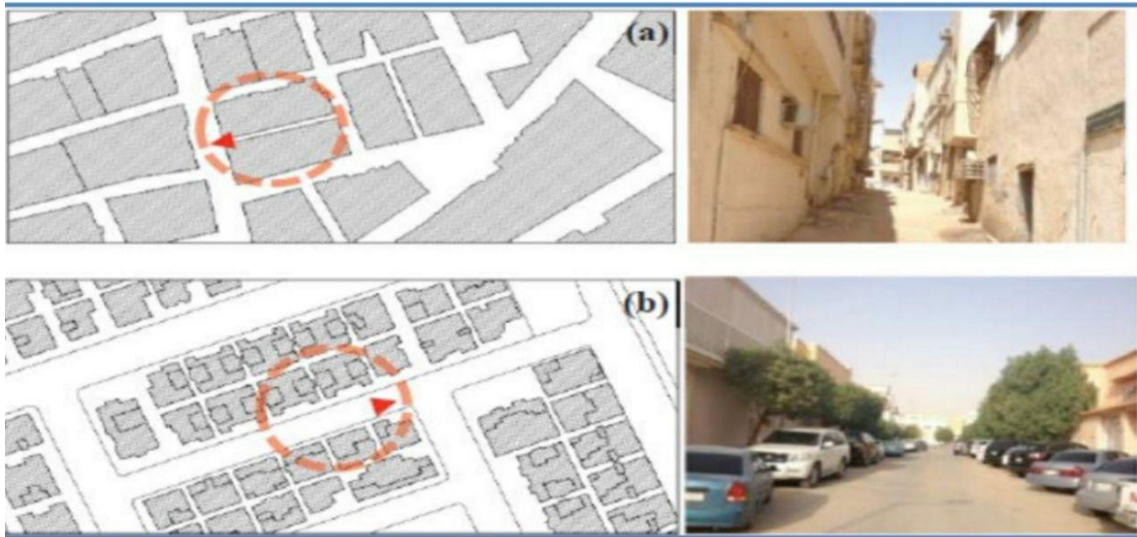


Figure (3-1): Aerial and street view (a) traditional area (b) modern residential area (Bakarman and Chang, 2015).

An investigation study was carried out in Morocco by Alaoui et al. (2016). The aspect ratio ($H/W > 2$) leads to an increase the energy cooling demand due

to the high thermal recession and the effect of low ventilation. An investigation study was conducted to evaluate the effect of different designs in Cairo, Egypt. Two different urban designs were selected: the renovated and non-renovated part of the alley, Fig. (3-2). The results showed that the non-renovated part of the alley improved pedestrian comfort due to higher aspect ratio and street geometry allowing to stop direct solar radiation in the alley (Mahgoub et al., 2013).



Figure (3-2): Different aspect ratio for two urban area geometries (Mahgoub et al., 2013).

3.4 Building orientation for hot and dry climate

The Orientation of the building should be done for the climatic zone in which the building is situated. The purpose of orientation is to provide residents with a comfortable living space throughout the year even under severe undesirable weather conditions.

Here we will discuss the orientation of building for maximum comfort under hot and dry climatic conditions.

3.5 Hot and dry climatic zones

Hot and dry climatic zones generally occur at This climatic condition generally occurs at the latitude between 15 degrees to 30 degrees on both the hemispheres. Maximum daytime summer temperature goes as high as 45 - degree centigrade and relative humidity as low up to 20 %.

This type of climate is experienced in areas far from sea coasts and do not receive heavy rainfall. Thus, the humidity is very low. So, the buildings in this climatic zone should be orientated based on solar point of view so that the building receives maximum solar radiation during the winter season and minimum radiation during the summer season.

3.6 the Orientation of building

the orientation of building in this climatic zone should be such that non-habitat rooms can be located on outer faces to act as a thermal barrier. Longer walls of the building should face North & South so that the building gets minimum solar exposure. Preferably the kitchen should be located on the leeward side of the building to avoid the circulation of hot air and smell from the kitchen.

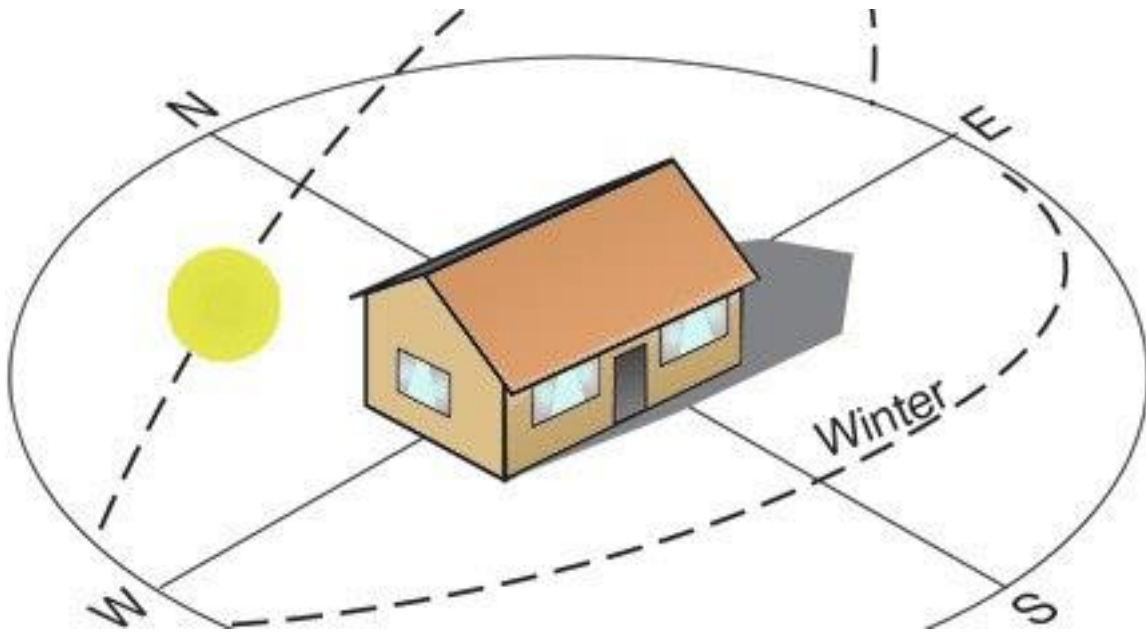


Figure (3-3): Orientation of the building

3.7 Windows and Openings in Walls

Windows and large openings in walls with heavy shutters should be provided on northern and western faces as light coming from the north is always diffused and indirect. Also, the direction of the breeze, which is from the west at most of the places, enters from opening on the west side. Windows area should be 15 to 20 percent of floor area.

Internal courtyard caters for cross ventilation and thermal buffer. Suitable radiation barriers in the form of canopies, long verandahs etc. should be provided on the West side of the building. The Sufficient number of ventilators close to the bottom of the slab should be provided for hot air to escape the room.

3.8 the Orientation of Walls

Thickness of wall plays an important role in heat insulation of the building. Thicker outer walls are preferred as it behaves as an insulating barrier. Painting of walls from outside also plays an important role. Walls with light and shining paints on the outer surface have good reflective quality and do not absorb heat. The surface of the walls should be smooth and non-dust catching type.

Walls constructed with hollow blocks/bricks and Cavity Walls can also be provided as they provide very good thermal insulation.

Orientation of Building

- The main living are located on the southern facing side and bedroom on north of the

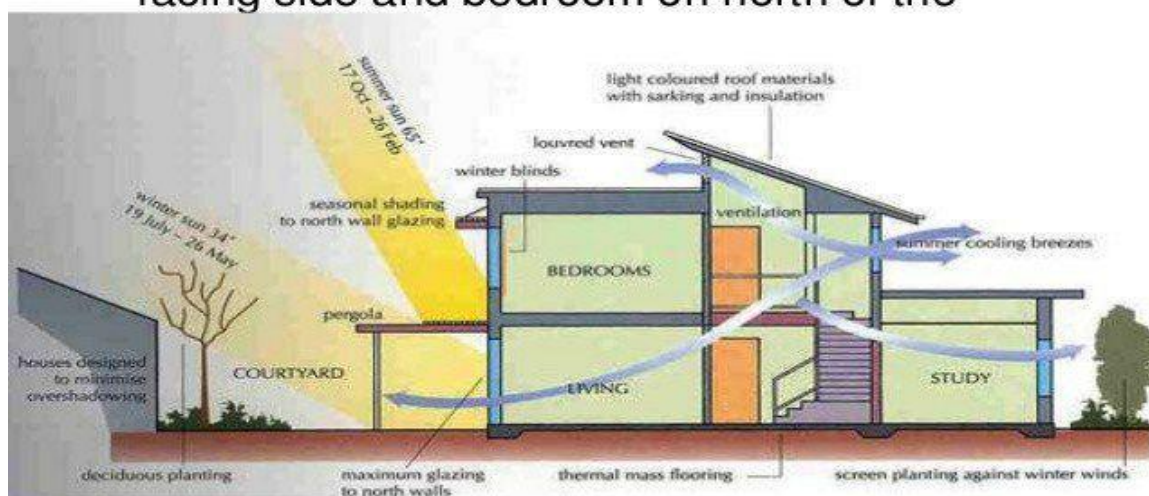


Figure (3-3) orientation of building

3.9 Insulation of Roofs

Roofs should be built up with good insulating material having slope in windward direction and which reflects the radiation and does not absorb heat. False ceiling can be used to improve the thermal performance of the building.

Terracing should be provided on the flat roof with mud, lime concrete, foamed concrete or burnt clay block paving over roof slab. Top roof surface should be made reflective by providing whitewashing or any reflective paint.

3.10 Growing of Vegetation

Large shady trees whose roots do not strain foundation and basement should be planted near external walls to provide shade.

3.11 Special Building Orientation Requirements

Outdoor sleeping area for summer nights preferably is provided. Desert coolers and fans can be used during summer months. Therefore, proper space to provide coolers should be planned in the building.

3.12 Understanding building orientation and how it benefits you

Most of the times, owing to the ignorance of the consumers, people ignore one of the most important parts of the construction. They don't ask any questions regarding the orientation of the building. In earlier times, it was one of the most important aspects as back then getting natural light and wind was of prime importance. However, nowadays with modernization, we have LED lights and Air Conditioners, so we don't feel their need anymore. Nevertheless, if you want to your home to be natural and sustainable, building orientation is one thing you must keep in mind.

Building orientation should be an essential part of your building design. You can get the benefits of natural light and maximum ventilation in all seasons and climate conditions. The right building orientation ensures comfort within the building/home, and it can make you save a lot on energy bills. The orientation of a building can also defend from the negative effects of inclement weather. If you're planning to construct a new home, you could ask the architect to design your home in such a manner that there is the least loss of energy.

3.13 Factors which affect building orientation

Solar and wind orientation are the two main factors which need to be thought about when you are constructing a new home/building.

3.13.1 Solar temperature and radiation

The solar radiation intensity is dependent on the direction of the sun's rays. A building's temperature and the interior temperature increases or decreases according to sun radiation. This radiation acts in two different ways –

The sun-rays enter a building/home through various openings and radiation comes in indirectly through roofs and walls of a building by absorbing the heat of the sun.

If you want to be comfortable during the summer, the best orientation is the one which gets the maximum sun's rays during winter and minimum during the summer.

If you're in a cold climate, there should be more openings in the Southern side of your building/home, which can be closed off by curtains or other closures that cut off the direct rays of the sun during summer. The reverse should be done in hot climates, as the building should have less solar radiation during summer.

3.13.2 How to reduce solar radiation in the south and western facades?

You can minimize solar heat which is reflected from the ground by growing a grassy patch in the front of the south façade. Both the western and eastern facades receive an equal amount of light. But when the sun is shining on the western side of the building in the afternoon, the temperature is higher, so you

have to get openings constructed on the western façade for more ventilation to reduce the heat.

3.13.3. Wind orientation

The wind direction and velocity should be studied at your site for the whole of the year. The building should be oriented in such a manner that the wind flow should be more in the building during the humid season than in other seasons.

The prevailing winds at your location can create natural ventilation, especially in highly humid conditions. The windows and doors should be at the proper locations to provide maximum advantage due to wind.

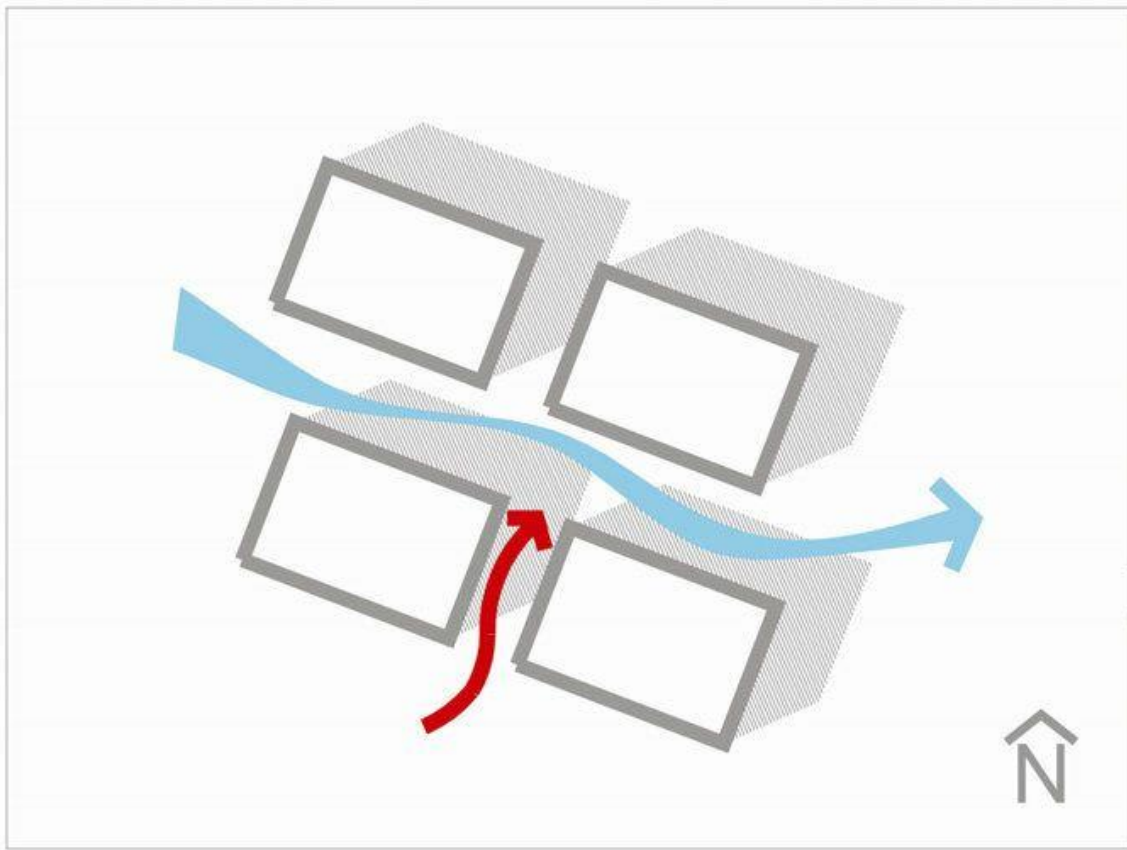
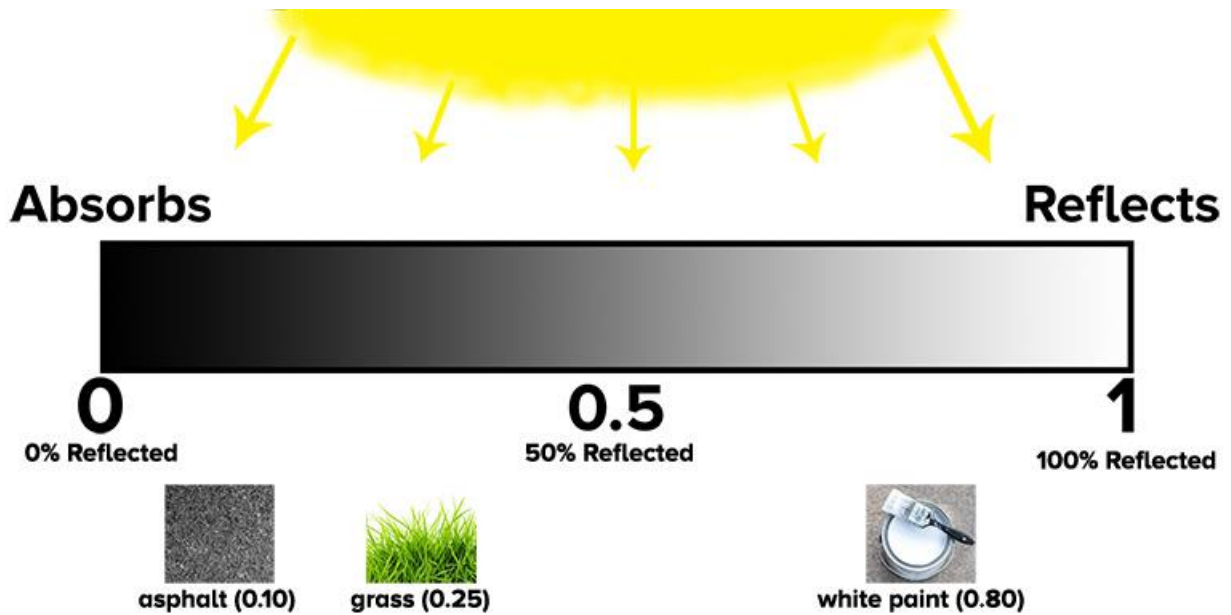


Figure (3-4)

Building orientation according to wind direction

3.14The albedo effects

Albedo is measured on a scale of 0-1. A 0 means that the surface of a material absorbs all of the sunlight that hits it. A 1 means that a material reflects all of the light energy that hits it. In other words, a 1 on the albedo scale means 100 percent reflection. A 0 means no reflection.



Albedo

Fig (3-5) Learn About Albedo

Fresh asphalt, for example, has an albedo of around 0.05, which means that only 5 percent of the light is reflected. The rest—95 percent—is absorbed.



Fig (3-6) fresh asphalt

In general, lighter-colored materials reflect more sunlight than darker colors and therefore have a higher albedo. Why do darker materials feel hotter than lighter ones when both are exposed to sunlight for a period of time?

When a material absorbs solar radiation, some of that light energy is converted into heat energy, and the material warms up. That's why an asphalt parking lot will feel hot if you walk across it on a sunny day.

3.15 Albedo and the Urban Heat Island Effect

In developed areas with lots of buildings and people, the effect of albedo can contribute to a phenomenon known as an urban heat island, which is a region whose average temperature is higher than surrounding rural areas.

UHI is a serious issue affecting many cities around the world. Green construction codes and green building rating systems try to address it by offering credits for porous paving systems and vegetative and structural shading of hardscapes. Many, but not all, encourage the use of lighter, concrete pavements because they have a higher initial albedo than darker asphalt pavements without regard for the fact that pavement albedo changes over time.

Effective UHI mitigation requires close consideration of the science and ensuring the intended goals are met without unintended consequences. However, most of the published studies on the issue focus on high-albedo rooftops or the combined effect of rooftops and hardscapes. These are the studies often used to support ground-level albedo modification — even though they don't assess albedo at the ground level.

Recently, researchers have begun to look at the actual impact of reflective pavements on UHI. One study concluded that, “Reflective pavements seem to have been the least effective methods of cooling urban temperatures Part of this is due to complicated urban geometry. Buildings often cast shadows on the pavements, limiting their ability to reflect energy.³ The studies of reflective pavements are also finding significant unintended consequences as a result of their use, including an increase in building cooling loads due to reflected solar radiation and increased human discomfort. For example:

- Increasing pavement solar reflectivity from 0.1 to 0.5 increased annual building cooling loads up to 11%.⁴
- Increasing pavement solar reflectivity from 0.15 to 0.5 substantially impacts the comfort of people standing or walking on the more reflective pavement, and increases the temperature they feel by 3°C to 6°C.⁵
- Infrared satellite imagery (Figure 3-7) demonstrates that darker pavements can be as cool or even cooler than reflective pavements.^{6,7}
- Reflective pavements can increase upward light scatter, adding to nighttime light pollution.⁸
- Widespread albedo modification has the potential to negatively impact regional hydroclimates and to reduce summertime precipitation

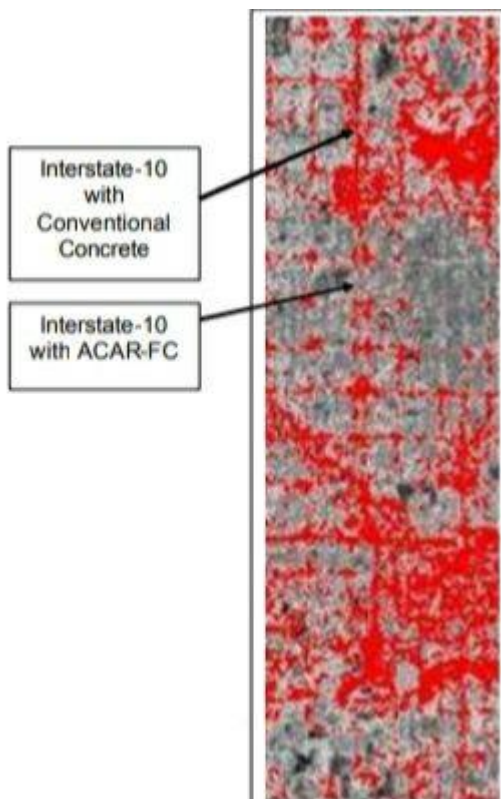


Figure3-7: ASTER Imagery of Pavement Variations. Phoenix, Arizona, October 30, 2003.⁷

Yang et al. (2015) provides a solid overview of these and other unintended consequences of reliance on albedo modification as a UHI mitigation strategy.¹⁰ Even if we disregard the unintended consequences, a key question remains: Does albedo modification help address anthropogenic climate change or does it simply mask the problem? A recent National Academy of Sciences study, *Climate Intervention: Reflecting Sunlight to Cool Earth*, says it's the latter. The authors write: "Albedo modification techniques mask the effects of greenhouse warming; they do not reduce greenhouse gas concentrations," and "It is far easier to modify Earth's albedo than to determine whether it should be done or what the consequences might be of such an action."¹¹ Similarly, a U.S. Department of Energy report on UHI

research found that “the challenges faced in measuring cool pavements as opposed to cool roofs are significant simply due to the complexity of measuring the pavement’s influence upon building energy demand — this implies that there still remain significant challenges to be overcome in establishing such estimates.

While using reflective pavements may seem a simple solution to the UHI problem, the science does not support its widespread adoption, and the identified unintended consequences could create additional problems as our urban areas seek to address climate change.

3.16 Using Trees and Vegetation to Reduce Heat Islands

Trees and other plants help cool the environment, making vegetation a simple and effective way to reduce urban heat islands. Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9°F (1–5°C). Trees and vegetation are most useful as a mitigation strategy when planted in strategic locations around buildings or to

shade pavement in parking lots and on streets. Researchers have found that planting deciduous trees or vines to the west is typically most effective for cooling a building, especially if they shade windows and part of the building's roof.



Fig (3-8) Using Trees and Vegetation to Reduce Heat Islands

3.17 Benefits and Costs

The use of trees and vegetation in the urban environment brings benefits beyond mitigating urban heat islands including:

- *Reduced energy use:* Trees and vegetation that directly shade buildings decrease demand for air conditioning.
- *Improved air quality and lower greenhouse gas emissions:* By reducing energy demand, trees and vegetation decrease the production of

associated air pollution and greenhouse gas emissions. They also remove air pollutants and store and sequester carbon dioxide.

- *Enhanced stormwater management and water quality:* Vegetation reduces runoff and improves water quality by absorbing and filtering rainwater.
- *Reduced pavement maintenance:* Tree shade can slow deterioration of street pavement, decreasing the amount of maintenance needed.
- *Improved quality of life:* Trees and vegetation provide aesthetic value, habitat for many species, and can reduce noise.

The primary costs associated with planting and maintaining trees or other vegetation include purchasing materials, initial planting, and ongoing maintenance activities such as pruning, pest and disease control, and irrigation.

A study of urban forestry programs in five U.S. cities showed a range of expenditures: annual costs ranged from almost \$15 per tree in the Desert Southwest region to \$65 per tree in Berkeley, California. Pruning was often the greatest expenditure, accounting for roughly 25–40% of total annual costs (approximately \$4–\$20/tree). Administration and inspection costs were the next largest expenditure, ranging from approximately 8–35% of annual expenditures (about \$4–\$6/tree). Tree planting, surprisingly, accounted for just 2–15% of total annual urban forestry expenditures (roughly \$0.50–\$4/tree) in these cities.

Although the benefits of urban forestry can vary considerably by community and tree species, they are almost always higher than the costs. The five-city study discussed above found that, on a per-tree basis, the cities accrued benefits ranging from about \$1.50–\$3.00 for every dollar invested. These cities spent roughly \$15–\$65 annually per tree, with net annual benefits ranging from approximately \$30–\$90 per tree.

● How the Heat Island Phenomenon occurs

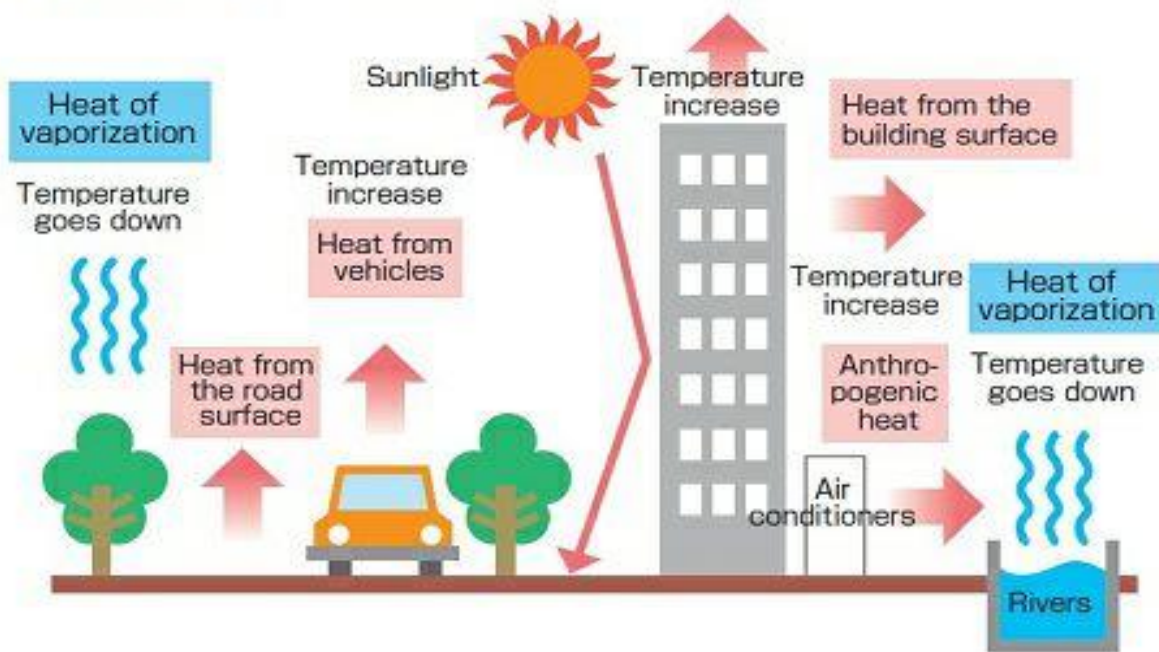


Fig (3-9) Reducing Urban Heat Islands with Trees

Chapter four

Applications and Recommendations



Chapter Four

Applications and Recommendations

4.1 Introduction

Firstly, the background of the Urban Heat Island (UHI) phenomenon and problems related to it will be discussed. Secondly, past efforts to establish models and tools to predict the heat island intensities of urban areas will be discussed. These are categorized in numerical models and empirical models. The Local Climate Zone (LCZ) classification will be briefly discussed as a means to guide heat island studies the most important studies conducted in hot areas to improve thermal comfort have been explained in this chapter

4.2.1 Thermal comfort studies on houses in hot arid climate (example one)

The traditional houses in Ghardaia City in Algeria had been built using traditional construction materials and passive solar design (PSD) strategies for the hot desert climate. These thousand-year-old houses are still standing and conditioning the harsh desert climate while maintaining indoor thermal comfort for its occupants. Of late, two trends of modern housing and construction were observed to have evolved in Ghardaia. Firstly, were the modern houses (Mod.H) following the international style and secondly, the

eco-friendly houses (Eco.H), modern houses but utilizing the passive solar design. The Mod .H was observed to implement some of the traditional features but using the modern construction material. Meanwhile, the Eco .H modified the

characteristics of the traditional construction and materials carefully in a modern context. Analyses were conducted to investigate the thermal performances of the three house designs. The intention was to ascertain the best construction that can achieve and maintain thermal comfort according to ANSI-ASHRAE 2014, in this harsh desert climate. Based on the Trad .H model, comfort data the two more modern houses were also monitored. Data collection was carried out in July, which was one of the hottest months. The study indicated that passive solar techniques employed in the Trad .H were able to maintain a comfortable indoor environment for the occupants without any mechanical aid. The indoor temperature of the Eco .H was 3 to 9 °C higher, and the Mod.H difference was 5 to 9°C above the thermal comfort zone. The study ascertained that designs of buildings with traditional construction and material played a significant role in moderating the indoor environment when the outdoor climate of the Algerian desert was unbearable. Inadvertently, energy for cooling was saved creating a significant impact not only on the economy both at the national and global level, but on the environmental scale as well.

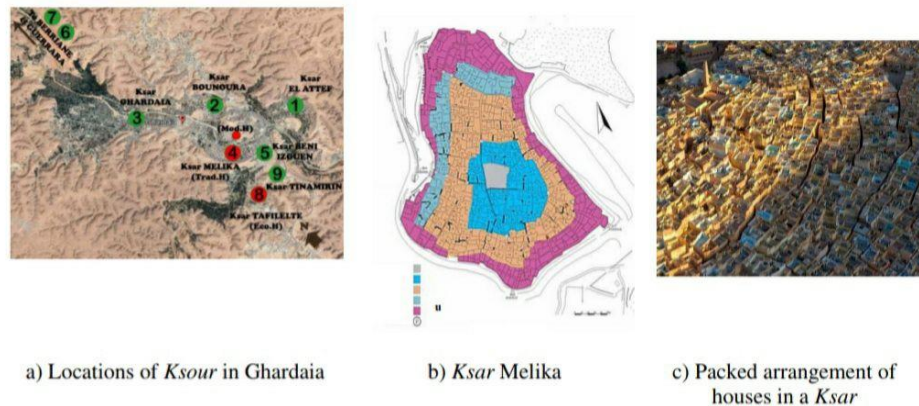


Figure (4-1) : Ksar/Ksour in Ghardaia city, Algeria

4.2.2 Methods

To understand the thermal performances of the various houses of the *Ksour* the methods undertaken in this study were the buildings measurement survey and climatic data monitoring. The building survey was pertinent for this study to get similar physical and climatic parameters for consistency of collected data and results. Three houses were selected due to their differing house types as required for this study and from different *Ksour*. The first is the Trad .H from *Ksar Melika*, the second a typical Mod .H (*not in any Ksar*) and the third a modern house but built with ecological principles (Eco .H) from *Ksar Taffilelt*. The three houses were selected, and physical measurements were taken and drawn on Archicad. The environmental parameters used for the analysis were indoor air temperature, relative humidity and the outdoor air temperature. The readings are taken during summer on various days in July 2017. Measuring instruments and devices include Onset data logger to measure relative humidity and air temperature continuously and the infra-red thermometer to measure the surface temperature.

4.2.3 Building descriptions

Modern house (Mod.H)

The Mod.H was constructed in 2000 and located approximately 1.5 km from the Trad.H. The layout of the buildings is different than the closely-packed Trad.H. This house is 73 sq.m. area and was constructed using 400 mm thick stone external walls in the basement level, 300 mm concrete external walls in upper floors and 100 mm thick internal walls of hollow concrete blocks. The materials used for the ceiling were the concrete compression slab of reinforced concrete beams and 200 mm thick reinforced concrete roof. The internal height of the rooms is 2.6 m. It has the most common layout in present- day modern houses.

Eco-friendly house (Eco.H)

The Eco.H, also constructed in 2000, was located in *Ksar Tafielt* with a built-up area is 96 sq. m. The construction materials used were stone, concrete and plaster. Stone exterior walls of 400 mm thick, constituted the building-supporting structure of the house as well as all the walls on the façade. The internal walls were made of hollow concrete blocks 150 mm thick. The materials used for the ceiling were the concrete compression slab of reinforced concrete beams, spaced 650 mm apart. The plaster vaults ensured thermal and sound insulation. The void between the compression slab and the vaults was filled with a mixture of lime and sand which were also used in the exterior cladding to allow better malleability of the mortar.

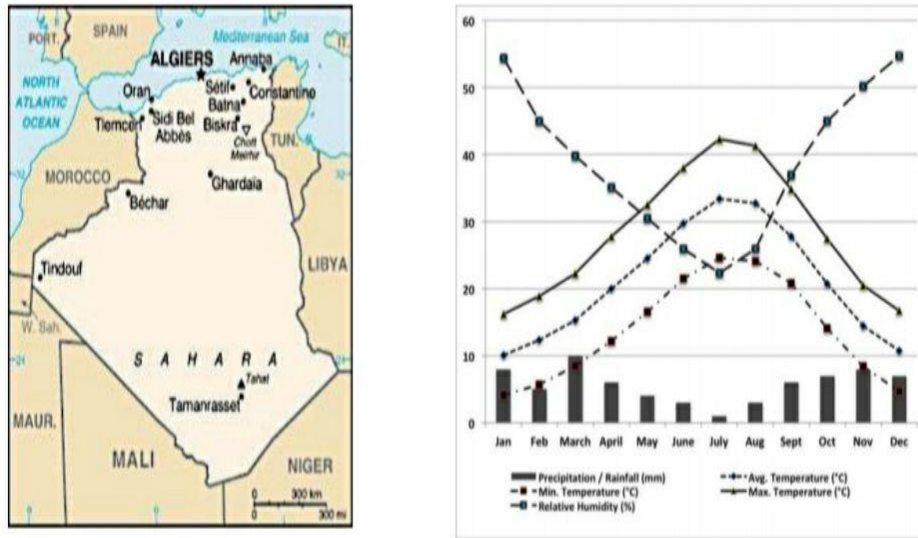


Figure (4-2): The location and climate of Ghardaia, Algeria

4.3.1 Effect of different pavements on human thermal comfort (example two)

The conditions of the urban heat island (UHI) phenomenon and outdoor human thermal comfort may be affected by several factors such as the size of the built environment, the rate of open and green spaces and different types of ground surface covers (e.g., grass and artificial covers) in urban areas. Depending on the types and structures of the pavement/covering materials, which can have effects on the albedo and surface heating, ground surfaces reflect solar radiation or heat the air above them. Pavements that can absorb more solar radiation may turn it into heat, thus warming the air, which in turn heats urban areas and make them uncomfortable for human beings. A present study investigates the effect of different materials on the UHI intensity by considering nine different types of materials (andesite, granite, basalt,

travertine, impregnated wood, soil, asphalt, clinker powder and grass) in the Ata botanical garden located in the city center of Erzurum, in the Eastern Anatolia region of Turkey. Temperature data were measured on clear summer days during July and compared in terms of thermal comfort. All measurements were taken 150 cm above the ground at noon by using an infrared thermometer (CEM-DT-8812). to estimate the physiologically equivalent temperature (PET) for each soil type, data were analyzed using the Rayman 2.1 software, and the scores were statistically analyzed with analysis of variance (ANOVA). The differences in mean temperatures were evaluated with Fisher's least significant difference (LSD) test. The results showed that mean PET scores ranged between 28.9 °C for impregnated wood and 25.9 °C for grass (a difference of 3.0 °C), while the other scores were 26.1, 26.7, 27.1, 27.5, 27.8, 28.5 and 28.5 °C for travertine, granite, andesite, soil, clinker powder, basalt, and asphalt, respectively. The analytical results indicated that all the studied materials create slight heat stress (23.1-29.0 °C) according to their PET indices and their predetermined comfort intervals. However the levels of heat stress for impregnated wood, asphalt, and basalt were higher than the others. It was determined that grass, travertine and cube granite are optimal surface materials, since they exhibited a level of heat stress that is close to the comfort range (18.1-23.0 °C).

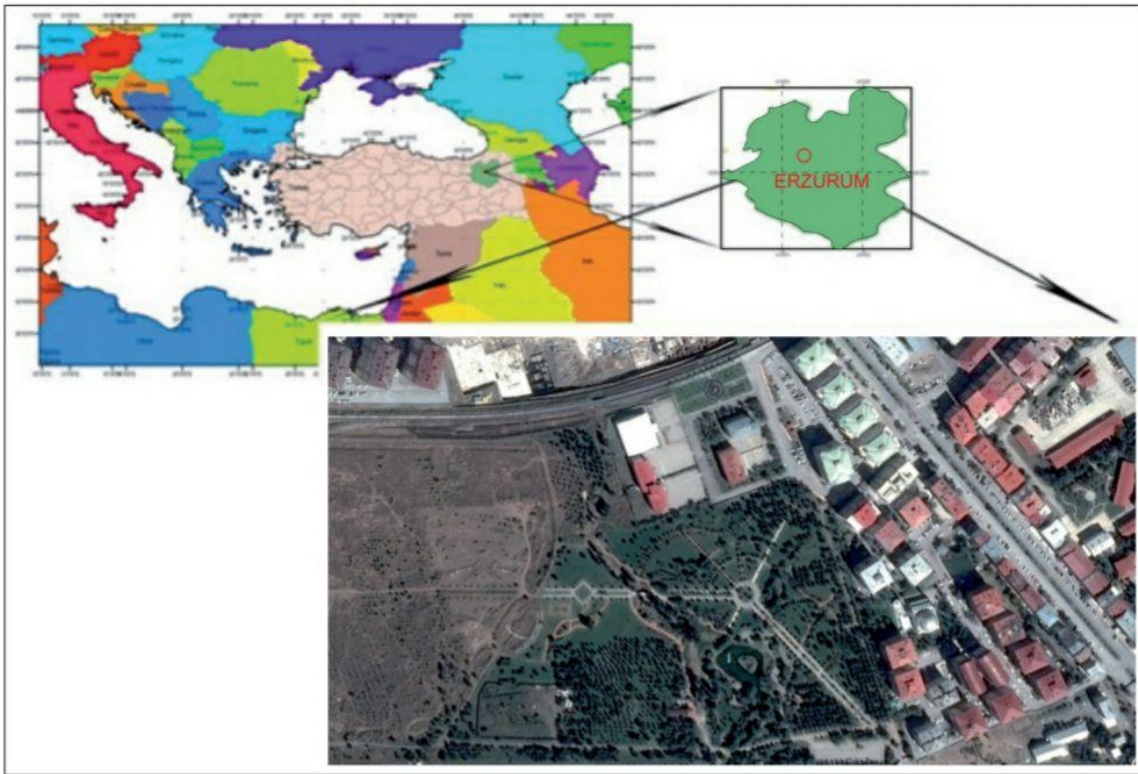


Fig. (4-3). Location of the study area (Ata botanical garden) at Erzurum, east Turkey ($39^{\circ} 54' \text{ N}$, $41^{\circ} 15' \text{ E}$).

4.3.2 Conclusions

, according the results of this study, the most appropriate materials for mitigation of the UHI and human comfort during the summer are grass, travertine and granite. Impregnated wood, asphalt and basalt should be used only in a limited manner within the design process, due to their characteristic high absorption

of heat. The limited use of these materials is crucial for mitigating the UHI effects. This study is useful to landscape and urban design professionals, whose commitment to urban environment reflects the need for livable cities and high thermal comfort levels in outdoor environments in order to increase the quality of life of human beings in urban areas. The results allow designers to select the most suitable surface materials for urban areas according to their thermal effects. Furthermore, urban and landscape designers may determine the effects of surface materials on human thermal comfort for every season. Therefore, designers can evaluate the adjustment possibilities of different surface materials on urban areas in terms of climatic conditions and contribute to the bioclimatic design of the urban environment. They can also determine the best uses for materials according to their thermal behavior. High-resolution thermal cameras and remote sensing methods need to be integrated in order to get more accurate results for improving outdoor thermal comfort. Additionally, this study should be reproduced in different seasons for those materials. The creation of climatic comfort in cities is a challenging task for urban and landscape designers. With this study, it is expected that the knowledge of the effects of surface materials in to urban thermal comfort will be integrated to urban and landscape design practices.

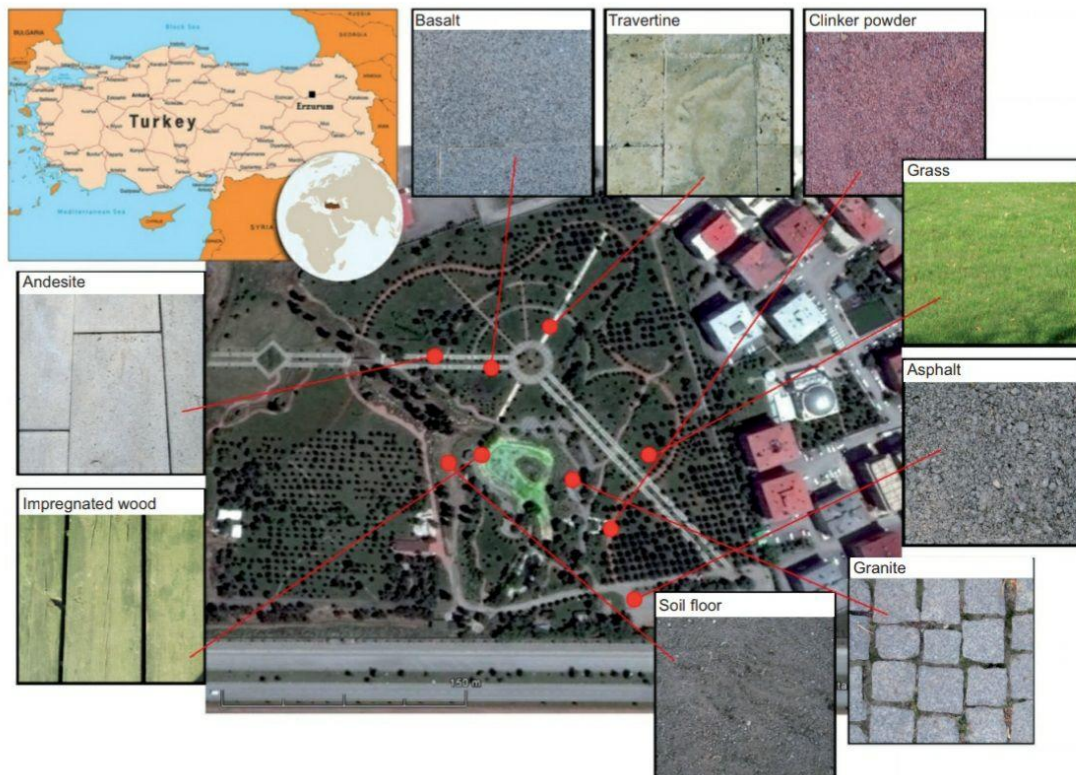


Fig. (4-4). Types of pavements and surfaces evaluated.

4.4.1 Optimal Thermal Characteristics of the Courtyard in the Hot and Arid Climate of Isfahan (example 3)

The courtyard is a common and traditional architectural concept in Middle Eastern countries, especially Iran. This study presents practical solutions to arrive at the optimal form and features of a courtyard based on this traditional architecture to cope with the hot and arid climate of Isfahan, Iran. A model using the ENVI-met 3.1 software was used to simulate the courtyard orientation, the height of the wall enclosure, the albedo of the materials and the vegetation level in Isfahan. As the first step of the simulation, different orientations were simulated. Based on the results, the northern courtyard is

recommended as the optimum orientation for the remainder of the simulation process. A high wall enclosure is recommended in the second step of simulation to ensure cool temperatures at noon and warmth at night. In the third step, it is advised to use low-albedo material in the courtyards to avoid the extra reflected radiation of used materials on the inhabitants. The final step suggests that more than 50% of the courtyard plan should be covered by greenery to ensure thermal comfort in the courtyards. Based on these suggestions, designers can create more sustainable courtyards that are better suited to the hot and arid climate of Isfahan.

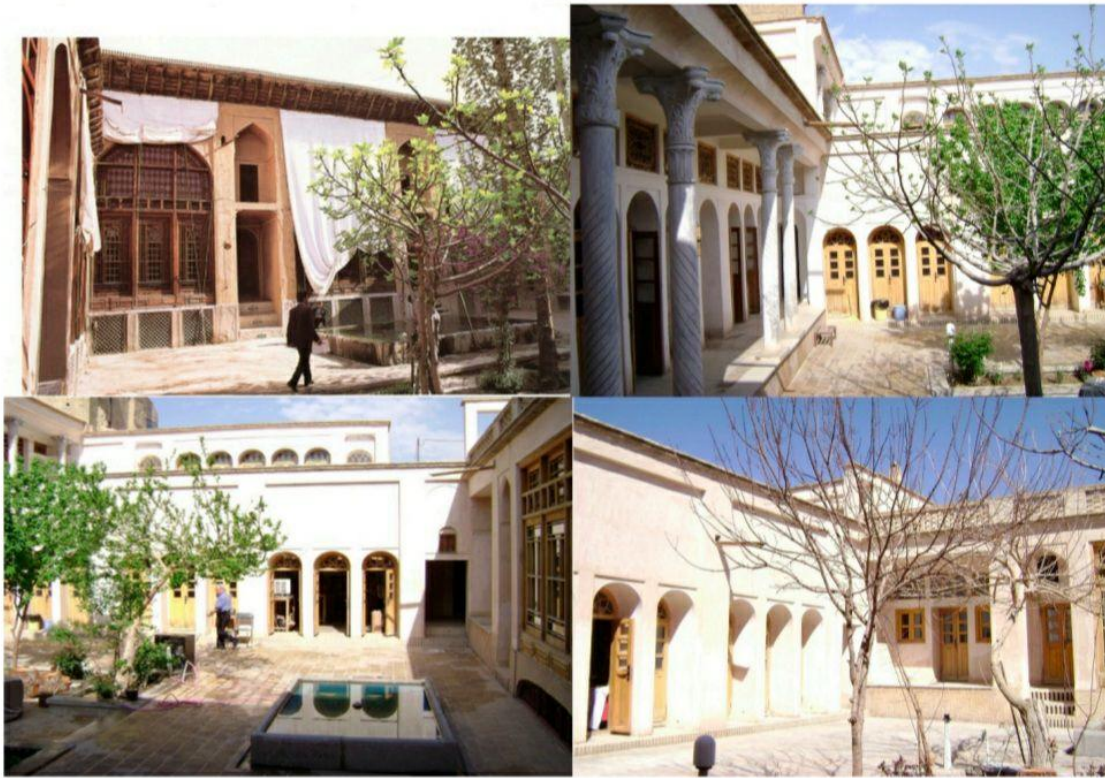


Figure (4-5) Example of common trees in the traditional courtyards of Isfahan

4.4.2 Conclusions

Open spaces and their thermal conditions by and large depend on physical features. Courtyards in traditional Iranian architecture as an open space for homes are well suited for the level of outdoor thermal comfort. Courtyards are mainly used in hot and arid climates. The lack of sufficient scientific studies about the physical features of courtyards makes the modern courtyard less effective in terms of thermal comfort.

The sky view factor (SVF) has a direct relation to the height of the walls of the central courtyard. Reducing this factor leads to stabilization of the temperature in the late hours of the day. Therefore, as the decreasing SVF duration of receiving direct solar radiation is limited by walls, by increasing the height (decreasing SVF), courtyards gain lower temperature duration in the early morning and critical hours of the day and higher temperatures in the late hours of day and night time. Because of the heat reflux (due to the albedo of the materials) of the walls, by increasing the height of the walls, the amount of reflected radiation increases. So, in the late hours of the day (after 17:00), the courtyards with higher walls have higher T_a . Therefore, it is important to assess the albedo of the wall materials in terms of the amount of reflected radiation. To examine the radiation effect on human thermal sensation, three common material categories were considered. Regarding this point that thermal stress conditions occur in the mid-hours of the day (13–16 h), the high-albedo materials reflect more sun rays to the environment, thus making pedestrians more prone to being in the heat stress range. Therefore, low-

albedo materials like brick are recommended for the hot and arid climate of Isfahan.

4.5 Recommendations

The evidence and conclusions from this work suggest the following recommendations preferably be taken into account in urban design in the hot, dry climate.

1. In a hot, arid climate, shading patterns and greenery strategies should be adopted for improving thermal comfort. The solar radiation intercepted by twigs and leaves of trees provides natural protection of outdoor spaces, mitigation of temperatures and reduce energy consumption on cooling indoor spaces.
2. In a hot, arid climate it is advisable to design corridors, arcs, parasols, and colonnades to protect pedestrians and provide sufficient thermal comfort.
3. Shadings pattern reduce the effect of solar radiation on building facades and ground surfaces. Accordingly, enhancing them to improve the thermal comfort is a good idea. The characteristics of shadings should be taken into account by professionals of the urban built environment to improve thermal comfort outdoors and lessen the effect of the Urban Heat Island, especially in extreme climate.
4. Construction materials play an important role in a hot, arid climate: the use of thick brick walls on the ground floor, and as walls overlooking the courtyard help to delay and reduce the heat gains from the hot exterior to the cooler interior and accordingly keep the interior relatively cool during the day in summer.
5. Narrow passages contribute to provide shadings at daytime and minimize

the amount of heat absorbed by the ground which leads to enhancing thermal comfort .

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دراسة وتقييم الإزدحامات المرورية وتأثيرها البيئي في منطقة باب
المعظم باستخدام التحسس النائي ونظم المعلومات الجغرافية

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2020-2019

المخلص

تعاني مدينة بغداد بشكل عام من مشكلة اساسية وهي الازدحامات المرورية والتي اثرت عليها بشكل خاص بيئيا وصحيا وعمرانيا واقتصاديا نتيجة لاسباب عديدة منها ازدياد النمو الحضري للسكان وازدياد اعداد المركبات فيهما كواقع لتلبية متطلبات المواطنين. الا ان هذا النمو لم يصاحبه اي تطور او تحديث في واقع شبكة الطرق الحالية، الامر الذي ادى الى زيادة حجوم التدفقات المرورية للطرق وبالتالي عجز الطرق عن تلبية مستوى الخدمة الذي صممت من اجله لضمان انسيابية حركة المرور مخلفة بذلك ازدحامات مرورية خانقة. تم اختيار منطقة باب المعظم لما تعانيه هذه المنطقة من اختناقات مرورية على مدى سنوات كثيرة وتأثير هذه الازدحامات على واقعها البيئي. تم في هذا البحث التطرق الى العوامل المسببة للاختناقات المرورية والاضرار الناتجة عنها من اجل وضع اليد على السبل الناجعة لحل هذه الازمة. اذ تم اجراء مسوحات حقلية ودراسات احصائية لتقييم اداء الطريق الحقيقي نسبة الى الزخم المروري الفعلي. كما تم قياس مقدار تراكيز المواد الملوثة في منطقة الدراسة لتقييم واقعها البيئي والصحي. النتائج المستحصلة من البيانات العملية تم تحليلها ومناقشتها. كذلك كان للمقترحات نصيبا في هذه الدراسة لمعالجة المشكلة الحقيقية التي تعاني منها هذه المنطقة.

Abstract

In general, Baghdad city suffers from a principle problem, which is traffic congestion, which has affected it in particular environmentally, healthily, urban and economically due to many reasons, including the increase in urban growth of the population and the increase in the number of vehicles in it as a reality to meet the requirements of citizens. However, this growth was not accompanied by any development or modernization in the reality of the current road network, which led to an increase in the volumes of traffic flows for the roads, Consequently, the inability of these roads to meet the level of service for which they were designed to ensure the flow of traffic, thus leaving stifling traffic congestion. Bab Al-Muadham area was chosen as a case study because it suffered for many years from the traffic congestion that affected its environmental reality. In this research, the factors causing traffic congestion and the resulting damages are addressed in order to lay hands on effective ways to solve this crisis. Field surveys and statistical studies were conducted to assess the real road performance relative to the actual traffic momentum. The amount of pollutant concentrations in the study area was measured to assess its environmental and health conditions. Results obtained from empirical data were analyzed and discussed. The suggested solution also had a share in this study to address the real problem plaguing this region.