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THE USE OF MICROCOMPUTERS IN ARCHITECTURAL AND CIVIL ENGINEERING

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Until a few years ago the use of computers in engineering applications was the privelege of large international architectural, engineering and design firms that could afford the costs of buying and maintaining computer systems. But with the development of affordable and powerfull microcomputers, Most of the engineering firms cannot afford to ignore the potentials of microcomputer systems. The easy availability of these systems is expected to cause major changes in the engineering practice.

These lectures are intended to give an introduction to microcomputers and to their applications in architecture and civil engineering.

FIRST: INTRODUCTION TO MICROCOMPUTERS HARDWARE COMPONENTS.

Any computer is composed of a Central Processing Unit (CPU) and a number of peripherals.With the development of " very large scale integration " (VLSI) ,the CPU has shrunk to occupy almost a single chip.

* (1) The Central Processing Unit (CPU)

The CPU consists of a microprocessorunit, a clock, Random Access Memory (RAM), and Read only Memory (ROM). In general the microprocessor unit and the clock reside on one chip and the memory (ROM+RAM) are external.

Microprocessors are devided into catagories depending on the length of data they can transfer.

- 8- bit microprocessor will transfer 8-bit data.
 Examples of these microprocessors are the intel 8080, 8085, the ziglo Z-80 etc.
- 16-bit microprocessor will transfer 16-bit data like the Intel 8086.
- 32-bit microprocessor will transfer 32-bit data. Examples are MC 68000.

The Random Access Memory (RAM) is the memory that can be read and written into during normal operations. The RAM capacity of microcomputers ranges between 4 k byte to 1000 K byte.

Note: (1 K byte = 1024 Bytes)

The Read Only Memory (ROM) contains fixed data that the computer needs for its operations.

*(2) The Peripherals

Information must be gatherd and processed by the Microcomputer. Once the information is processed it has to be displayed. This procedure of transforming information between the microcomputer and the outside. world requires input-output (I/O) devices which are peripherals.

- a) <u>The Key board</u>: which is common to every microcomputer. It consists of pressure or touch activated swiches.
- b) <u>The Monitor</u> : -which is a screen that displays the output. There are two types of monitors.
 - 1) CRT (Cathod Ray Tube) monitors.

The most common CRT is the television set. There are other advanced types of CRT like the monochrome displays, which are prefered for displaying texts. Color RGB displays are prefered for graphics. Graphics capability is not always integrated to the system but it can be added as an advanced option. Flat screens like the liquid crystal displays.

c) Long term storing devices

In order to save programmes and relcad them when needed some form of long term storage is necessary. There are different types of longterm storing devices:-

1) A cesstte recorde,

The inexpensive portable cassette tape recorde, can be used to store and load digital information. But the process of loading and unloading the data is very slow.

2) A Floppy Disk (Diskette)

A floppy disk is a disk coated with magnetic materials and devided into sectors and tracks, on which data is recorded. It provides a high speed access and a large capacity. There are different types of floppy disks like single sided double sided, single density and/or double density. They are also different sizes of floppy disks which are 8", $5\frac{1}{4}$ " and $3\frac{1}{2}$ ".

A disk drive is used to store data on the diskette. The drive houses the mechanical functions and electronics required to rotate the diskette and access the data. The diskette capacity ranges between 180 K bytes and 1 Mag byte (1000 K Byte).

3) A Hand Disk

Where a huge amount of data can be stored (5 M Bytes -70 M Bytes). There are different types of hard disk drives.

- i) Hard-disk with tape backup,
- ii) Cartridge hard-disk drive,
- iii) Fixed hard-disk drive.

d) Printers

If a hard copy of the data is needed a printer is a must. Printers are grouped under the following catagories:-

- a) Dot Matrix Printer, in which the letter is made of dots. The speed of the dot-matrix printer ranges from 80 CPS to 500 CPS (Character Per Second).
- b) Letter qualify printer, in which the letters are like the typewriter's. Its speed ranges from 10 CPS to 55 CPS.
- c) Jet Inc. Printer.
- e) Plotters

Plotters are essential in computer aided design and drafting CADD systems. There are two main types of plotters

i) x - y plotters

ii) Drum plotters

Plotters also very widely depending on the size of the output drawing, the number of colours used and the speed of the plotter.

f) Other Peripherals

- Communication modem and software.
- Network kits
- Mouse
- Light pens
- Touch pads

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- Mathematical coprosessors
- etc.

g) Interfaces

Note that every peripherals should be connected to the CPU using a suitable interface unit. Interforces are either parallel or serial.

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MICROCOMPUTERS CLASSIFICATIONS

The distinguishing microcomputers characteristics are as follows:-

1- The Business Personal Computer (categorized)

(Categorized as \$.7K) costs about \$.5K-16K and is typified by the Apple III, TRS 80 Model 16, the Altos ACS 8000, or IBM-XT.The key product differentiation is Winchester disk mass storage and a minifloppy disk for software media. The display is usually monone chrome with 80 columns. Multi-user capability is also common. Apple's lisa is in this class.

2- The Professional Personal Computer.

(Categorized as \$3K) costs about \$.1.500-\$5,000 and has the Apple II and IBM Personal Computer as the main products. Distinct characteristics are color graphics for a TV or 80-column monochrome display and dual minifloppy disks.

3- The Home Computer with Peripherals.

(Categorized as \$1K) costs $500 \ 5,000$ and is typified by the Atari 800 and TI-99/4A. This product must have color graphics for a TV and a ROM Cartridge for software media. Cassette and minifloppy are also used for software media.

4- The Entertainment Home Computer.

Now costs \$200-\$1,000 and include the Atari 400, TI-99/4A and VIC-20. This product must also have the TV color graphics and ROM Cartridge. Cassettes are again used for software media.

5- The Computer Literary Home Computer.

Now costs less than \$100. This product was pioneered by the Sinclair ZX80/81 which is now marketed by Timex in the U.S. Texas Instruments. just introduced the 99/2 which is a powerful product with ROM Cartridge and 16-bit microcomprocessor (TMS 9995). Amonochrome TV is used for display and most software comes on cassette. The distinguishing product characteristics of the portable personal computers are as follows:-

A- The Portable Business Personal Computer.

Costs about \$6,000 \$10,000. The distinguishing characteristics are a Winchester disk or bubble memory and mini-or microfloppy disk. The display is 80 x 24 characters using either a small CRT or a flat display. This is a brand new product class. The closest product is the Jonos Courier with a microfloppy and micro-Winchester and 9 CRI.

B- The Portable Professional Personal Computer.

Costs about \$2,000-\$5,000. The main product is the Osborne 1, with several newcomers such as the Otrona Attache and KayPro II. The \$3K portable computer has two minifloppies or microfloppies and 40-80 column display.

C- The Book-Size Personal Computer.

Costs about \$1,000 \$2,000. The product characteristics include a multiline display, full keyboard and battery power. The product class is brand new and the closest product is the Epson HX - 20. The Epson has a 4 x 20 character display, 20-column printer and microcassette. The new HP-75C and TI CO-40 also fit in this product category.

D- The Handheld Personal Computer.

Costs about \$200-\$1.000. The main product is Radio Shack's TRS-80 Pocket Computer which is made by Sharp and also sold as the Sharp 1500 series. The key characteristics are battery power, single-line display and full alphanumeric keyboard. The Panasonic HHC or link fit in this product category, but with added peripherals it is expandable all the way to a \$3,000 briefcase computers.

SECOND: INTRODUCTION TO MICROCOMPUTERS'

SOFTWARE

There are basically two kinds of software as shown in table No.4. System software controls the operation of the computer and help to develop other kinds of software. Application software is what makes the microcomputer solves a specific problem.

A) SYSTEM SOFTWARE

As shown in table No.4 system software has three catagories:-

1) The Operating Systems.

The operating system that controls the operation of the microcomputer and all its peripherals. The operating system is the basis on which application software is organized. Each application program must be customized to a particular operating system.

2) Language Compilers.

All application software is written in specific languages. All microcomputers come with a Basic Language built in. Other more powerful languages such as Fortran, Assembly language, Pascal, Cobol and C Language are available to microcomputers.

Utilities.

Utilities are various software tools that enhance the development of application programmes.

B) APPLICATION SOFTWARE.

Table No.4 shows the different catagories of application software. Table No.5 gives the subcatagories _ and some product examples.

Every application software has a life cycle. Figure (1) shows a typical life cycle of productivity software. It shows that after nearly one year a new enhanced version of the program is released. That is to keep up with the new development in hardware and to match the new and improved competitors.

Table No.(6) shows the main differences between the software used for each catagory of hardware.

There are many potential microcomputer applications in civil engineering. But the software development lags far behind hardware development in the specific area of technical engineering. I will try to give a partial list of these application and the software available.

Civil Engineering software applications can be devided into the following catagories:-

- STRUCTURAL ANALYSIS PROGRAMS

These programmes calculate the Bending Moment, Shearing Force and Normal Force of the different structural element. The programmes also calculate the deflections of the structure.

A good structural analysis program should have the following features:-

- Based on matrix analysis of structures and the finite element method (F.E.M.).
- The theoretical documentations should be available to the user.
- Be capable of performing large as well as small size problems with considerable efficency.
- Be capable of performing 2-D and 3-D analysis.
- Include an automatic generation option that minimizes the storage of data.
- Have a preprocessor subroutines to help inputing the data in a user friendly environment (interactive or free format).

- Be equipped with an interactive graphics capability to simplify checking the input and output data.
- Perform the analysis of any type of loading conditions and obtain the critical design values for the different loading combinations.
- Have automatic data generation option.

Some examples of the available Structure Analysis programs are:-

1) ECOM frame programmes perform 2-D analysis.

2) Stress 2-D

- 3) STAAD III which is based on F.E.M performs 2-D and 3-D analysis and has an optional graphics package.
- 4) ETABS 84 Has the following features:-
 - 3-D Frame and shear wall analysis
 - Static and dynamic analysis
 - Graphics output
 - Large capacity
 - Has a post proessor for steel or concrete design.

5) SAP-80 Series

which area microcomputer version of one of the most widely used structural analysis programmes (SAP). It performs static and dynamic analysis of 3-D frames, trusses, shells and plates. It has also graphics capability.

<u>NOTE</u>: - Both ETABS - 84 and SAP - 80 require large storage (Hard Disk).

STRUCTURAL DESIGN PROGRAMS

These programmes obtain the dimensions and reinforcement of the structure elements. They are based on different specifications. A good structural design programme should have the following feactures:-

- Has good documentations discribing the solution algorithms and the code used.
- Flexible enough to be internupted by the engineer to change or modify some date.
- The input is easy to prepare.
- The output is easy to interpret.
- The load factors or factor of safety can be given as input by the user.
- Based on some optomization techniques to arrive to an optimum design.

Some examples of the available design programmes are:-

The Portland Cement Association (PCA) programmes such asy--

1) ADOSS	For slab analysis and design.
2) PCA Col.	" Column design.
3) Mats	Design raft foundations
4) BOX GIRDED	For design box girdes bridge
	design.

- 5) Etc.
- II) ECOM Design package for beam column and spreadfooting design.
- III) STAAD III with steel or concrete design

IV) ETABS - 84 has 2 post processors for:-

- a) Concrete design (CONKER)
- b) Steel design (Steeler)
- V) STRUDEL

- SURVEYING PROGRAMS

Surveying programs was introduced to the microcomputer long before structural engineering programs because of their Natural A. good surveying program should have these features.

- Computational Accuracy.
- The input data should be easy to prepare.
- Plotting capability on a plotter and on the screen.
- The commands are in a form of a menu.

Some examples of these programs are:-

1) COGO - PC and COGO 86

Which is the microcomputer version of the well known COGO " Coordinate Geometry " program which can be used for subdivision mapping, tract maps and field surveys. It has large capacity and plotting capabilities.

2) EARTHWK

EARTHWK is an interactive earthwork program which is used for cut and fill calculations for given cross sections along an alignment.

- HYDRAULICS PROGRAMS: -

These programs perform water system analysis. Examples of these programs are:-

- Pipe net work analysis programs such as " WATER " or " NET ".
- Hydraulic characteristics of a natural channel such as " NCH ".
- Modeling of sanitary sewage collection systems such as " SEWER ".

PROJECT_MANAGEMENT_PROGRAM\$

Which perform the scheduling of multitask projects, and critical path analysis.

Examples of these programs are:-

- 1) Pert Master
- PMS-11/RMS-11 (Project Management System/

Resource Management System) 3) CPM-PERT

- QUALITY CONTROL PROGRAMS

+ STEEL BAR DETAILING PROGRAMS

- COAST ESTIMATE PROGRAMS

It is expected that the in next few years. Their will be a revelotution in the software development. More powerful yet cheaper programs will be developed soon.

Final remarks on the use of Microcomputer in Civil Engineering.

As we mentioned earlier that the introduction of microcomputers will cause a revolution in the Engineering practice. Computer aided design has many obvious advantages such as accuracy, speed, capability of performing large jobs and preciseness. But the disadvantages of microcomputers are not so obvious. Among these disadvantages:-

- Over confidence in the results because it is done by
 " Computer " may make us to accept incorrect results.
- 2) Misinterpretation of the results may occur.
- 3) The danger of incorrectly inputing data for the computer.
- 4) Some types of problems is very sensible to the computers mathematical capability and they may give incorrect results even with the correct data input.
- The use of the computers may cause a loss of manual computational skills and intuitive engineering judgement.

GAME MACHINE	PRODUCTIVITY TOOL	HOME BUSINESS MANGEMENT
16KB RAM RF MODULATOR JOYSTICK CASSETTE ENTERTAINMENT SOFTWARE EDUCATION SOFTWARE	 32KB RAM RF MODULATOR JOYSTICK SINGLE MINIFLOPPY DISK ENTERTAINMENT SOFTWARE BUDGETING SOFTWARE ELECTRONIC FILING SOFTWARE SPREADSHEET 	 48KB RAM RF MODULATOR JOYSTICK SINGLE MINIFLOPPY DISK MATRIX PRINTER ENTERTAINMENT SOFTWARE WORD PROCESSING SOFTWARE SPREADSHEET ELECTRONIC FILING SOFTWARE HOME FINANCIAL MANAGEMENT EDUCATION SOFTWARE
<u>\$400-500</u>	<u>\$1,000-1200</u>	<u>\$1,500-2,000</u>

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TABLE 1

ENTERTAINMENT SYSTEM	PRODUCTIVITY TOOL	WORD PROCESSING SYSTEM
 48KB RAM RF MODULATOR SINGLE MINIFLOPPY ENTERTAINMENT SOFTWARE 	 128 KB RAM CRT MONITOR Dual MINIFLOPPY MATRIX PRINTER OPERATING SYSTEM DATA BASE OR SPREADSHEET. SOFTWARE 	 64KB RAM CRT MONITOR DUAL MINIFLOPPY LETTER QUALITY PRINTER OPERATING SYSTEM WORD PROCESSING SOFTWARE
<u>\$1,500</u>	<u>\$3,000</u>	<u>\$4,500</u>

TABLE 2

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PRODUCTIVITY TOOL	SMALL BUSINESS COMPUTER	MULTI-PURPOSE WORKSTATION
 128KB RAM B/W MONITOR SINGLE MINIFLOPPY DISK WINCHESTER DISK DATA BASE SOFTWARE SPREADSHEET SOFTWARE MATRIX PRINTER 	 256KB RAM B/W MONITOR SINGLE MINIFLOPPY DISK WINCHESTER DISK LETTER QUALITY PRINTER WORD PROCESSING SOFTWARE ACCOUNTING SOFTWARE 	 256KB RAM B/W MONITOR SINGLE MINIFLOPPY DISK WINCHESTER DISK LETTER QUALITY PRINTER DATA BASE SOFTWARE SPREADSHEET SOFTWARE WORD PROCESSING SOFTWARE GRAPHICS SOFTWARE
\$3-5,000	\$10+12,700	<u>\$9-11,1000</u>

	PERSONAL COMPUTE	R SOFTWARE CATEGORIES	
	SOFTWARE CATEGORY	FUNCTION PERFORMED	
OPE SYSTEM SOFTWARE LAN UTI	OPERATING SYSTEM	CONTROLS THE OPERATION OF THE PERSONAL COMPUTER	
	LANGUAGES	IMPROVES THE PRODUCTIVITY OF DEVELOPING APPLICATION SOFTWARE	
	UTILITIES	PROVIDES TOOLS TO ENHANCE DEVELOPMENT OF APPLICATION SOFTWARE	
APPLICATION Software	ENTERTAINMENT	TURNS THE COMPUTER INTO AN ENTERTAINMENT MACHINE INCLUDING GAME PLAYING, MUSIC AND OTHER RECREATIONAL ACTIVITIES	
	EDUCATION	TURNS THE COMPUTER INTO A TEACHING MACHINE FOR HOME, SCHOOL OR BUSINESS	
	PRODUCTIVITY	IMPROVES THE PRODUCTIVITY OF COMMON TASKS SUCH AS TYPING, FINANCIAL PLANNING AND RECORD KEEPING	
	SCIENTIFIC/ENGINEERING	SOLVES ENGINEERING, SCIENTIFIC AND MATHEMATICAL PROBLEMS	
	BUSINESS	BOOKKEEPING FOR A SMALL BUSINESS	

TABLE 4

	APPLICATION SOFTWARE T	YPES	
APPLICATIONS	TYPICAL SUB-CATEGORIES	PRODUCT EXAMPLES	
ENTERTAINMENT	 ACTION GAMES STRATEGY GAMES SIMULATION GAMES OTHERS 	 RASTER BLASTER WIZARDRY ROBOT WAR 	
EDUCATION	 MATHEMATICS READING SCIENCE OTHERS 	 DUELING DIGITS COMPU-READ ECOLOGY SIMULATIONS 	
PRODUCTIVITY	 WORD PROCESSING FINANCIAL PLANNING DATA BASE GRAPHICS OTHERS 	 WORDSTAR VISICALC PERSONAL FILING SYSTEM (PFS) PFS:GRAPH 	
Scientific- Engineering	 MATHEMATICS ELECTRICAL ENGINEERING GRAPHICS OTHERS 	 TK!Solver AC CIRCUIT ANALYSIS SCIENTIFIC PLOTTING 	
BUSINESS	 HORIZONTAL ACCOUNTING VERTICAL ACCOUNTING 	 PEACHTREE GENERAL LEDGER MEDICAL BILLING 	

TABLE 5

	SOFTWARE FOR \$1K SYSTEMS	SOFTWARE FOR \$3K SYSTEMS	SOFTWARE FOR \$10K SYSTEMS
SOFTWARE MEDIA	ROM CARTRIDGE CASSETTE	• DISKETTE	• DISKETTE
MEMORY SIZE ASSUMED	16K BYTES OR LESS IS TYPICAL	32K BYTES OR LARGER	64K BYTES OR LARGER
MASS STORAGE ASSUMED	CASSETTE	MINIFLOPPY DISK	FLOPPY DISKHARD DISK
OPERATING SYSTEM ASSUMED	NONE, BUILT INTO BASIC INTERPRETER	• SINGLE-USER	SINGLE-USER MULTI-USER
TYPICAL PRICE	• \$20 - 150	• \$30 - 600	• \$150 - 2,000
USER INTERFACE	EASIEST TO LEARN (MINUTES)	EASIER TO LEARN (HOURS)	EASY TO LEARN (FEW DAYS)
CAPABILITIES	LIMITED	SUBSTANTIAL	EXTENSIVE
TYPICAL LANGUAGES USED	BASIC ASSEMBLY	BASIC ASSEMBLY PASCAL	 BASIC COBOL FORTRAN ASSEMBLY PASCAL

There are several differences between the software for \$1K systems, \$3K systems and \$10K systems, as shown above. The most important differences are the memory size, mass

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storage and software media. The results are that price and capabilities are increasing to the right of the figure.



The personal computer productivity hit programs have different sales profiles from entertainment software. It takes 6-8 months until the sales peak is reached. To sustain the sales momentum, enhanced versions must be released approximately once per year. The yearly sales for hit programs range from 30-100K units, and are growing as the shipment rate of personal computers grows.

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Figure 1