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General Purpose Pre- and Post-Processor of Matrix Structural Analysis Program

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Matrix Structural Analysis Package developed at Central Building Research Institute is a general purpose processor for the analysis of 2D/3D trusses, frames, and grids based on stiffness matrix method. The input data file required for analysis is presently required to be fed manually. In order to reduce the monotony and tedium of preparing error-free data file, a need was felt to augment SFP with a pre-processor. Similarly, it is difficult to comprehend the output (result) file without the aid of a post-processor. In order to make the package user-friendly for data preparation as well as interpretation of the results, pre- and post-processors have been developed in Turbo 'C'. This paper discusses the salient features of the pre- and post-processors with illustrative example.

INTRODUCTION

re are three phases in the structural analysis by matrix lded, namely, data preparation, *ie*, pre-processing phase; lution phase; and post-processing phase, *ie*, comprehension understanding of the forces/deformation in the structure.

processing phase includes description of the problems by ating the nodes, element connectivity, material and con- int (boundary conditions) definitions, load description finally, the display of model. Post-processing phase en- s processing of the forces and deformations for better ciation of the results from printout of reactions, dis- ments and member end forces as per the designer re- ments supplemented by displays of displacements/axial s/shear forces/bending moments as desired.

st of the packages developed earlier do not have pre- and processing modules separately. Nowadays, in the fast putational era with modern computers, it has become rial to support any package with pre- and post-proces- so that preparation of data becomes user-friendly, free error and the forces and deformations of the structures me more easily comprehensible with on-line graphic lays.

his paper, an attempt has been made to supplement a viously developed general structural analysis program by ffness matrix method with pre- and post-processors. These essors are designed to be user-friendly. Being interactive supported by help menu on each command, it requires no ral skill from the user. The basic input to the processors raightforward and can be easily mastered.

processors have been developed in such a way that they self-explanatory with minimum dependence on the in- ion manual[1]. They have also the facility of displaying put or output data on the monitor in printed or graphical

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MAIN ROUTINES INVOLVED IN THE COMPLETE ANALYSIS

The main routines associated with the phases are as follows.

PREP

This routine is used for preparing input data file in an interactive mode and can be invoked by giving 'prep' command.

SFP

This is the matrix structural analysis program for solution of 2D/3D trusses, frames, and grid floors. Once the pre-processing is completed, the user has a readymade data file which can be fed to SFP in solution phase.

POST

After the structural analysis is over and the solution is obtained, the result file is ready for the post-processing. The user may carry through various post-processing operations.

In fact, these three routines are independent of each other and are to be invoked at DOS prompt level separately. They interact with each other only through files which are created during pre-processing and solution phases. Generally, pre-processing is done interactively so that one can have direct communication with the computer along with on-line graphic display. The solution phase is done as a batch job and then post-processing is again interactive.

PRE-PROCESSING

All input data like node/element generation, the material properties, nodal constraints, loading conditions, etc are prepared in this routine. All data generated in the pre-processor are stored in various files. The files associated with pre-processing are F18.DAT, F27.DAT, F23. DAT, RES, and INPUT.DAT.

Data Input

The pre-processing is done through a routine 'prep' developed in Turbo 'C'. As 'prep' is given at the DOS prompt level, the screen gets cleared and the following message appears at the bottom left of the screen.

Begin Inp module =

...level, there are two ways to input the data:

The command 'prep' takes the user to the pre-processing module and allows to work on a new data to be created interactively, and

The command 'inp, filename' will ask the name of a input file prepared earlier. It will allow the user to work further on that file for possible modifications, additions, etc.

...Description of Commands

...the user is in pre-processing module, one may start ...ing by using pre-processing commands. The description ...the commands is given in Appendix I in the logical ... Commands like 'title', 'kan', 'r', 'ex', 'gx' should be ...first since they are the basic control parameters which ...ed to define data to be generated later.

...ST-PROCESSING

...post-processing is done as a separate phase which fol... the solution phase. The post-processor is used for prin... and displaying selected results. The basic geometrical ...ures of the structure are available in this routine for ...ing and display.

...ut data may be further selected based on the ranges of ...eral parameters, *ie*, node numbers, element numbers and ...m different load cases. Selected data may be printed ...maximum and minimum values. Graphic displays cor...ponding to selected results may be made. Displacement, ...tion forces and member end forces may also be printed. ...phic display of displacement and forces (axial force/shear ...bending moment) on the whole or part of the structure ...so possible.

...in Routines

...e post-processor has got two modules, namely, post-pro...ing module and plotting module. Post-processing module ...sponsible mainly for printout of results and the plotting ...ule, as the name suggests, is used for plotting the basic ...ctures, forces, and displacements. From post-processing ...ule, the plotting module may be called by giving com...nd 'plot' and from plotting module, one may switch over ...post-processing module by giving 'eof' command. In...ally, the post-processor will be in post-processing module.

...ta Input

...e post-processing is done through a routine 'post' deve...ped in Turbo 'C'. As 'post' is given at the DOS prompt ...ed, the screen gets cleared and the following message ...pears at the top left of the screen.

Give the name of the output file?

...t-processor initially requests for a file (the post-data file) ...m which data is to be read for further processing. Once the ...e of the file is given, the screen gets cleared and the ...owing message appears at the bottom left of the screen.

Post-processing module

...this juncture, the user may start working further in the ...t-processor with the post-processing commands available.

...ad Cases

...t-processor automatically finds the last load case. How...r, an option exists to go to the desired load case and carry out the post-processing for that particular load case (the 'set' command).

Brief Description of the Commands

The input commands for post-processing are detailed out in Appendix II. The commands are of two types: (i) specification commands, and (ii) action commands.

If specification is not provided before the action command, the default value will be used. If some specifications are changed after the command, the changed specifications and the remaining previous specifications will be used for the next action command. If specifications are defined more than once before the action command, the last specification is used.

Output

The output from the post-processor is generally printouts and displays. The output may be taken for a selected set of nodes or elements or for a whole and may be displayed on a graphic terminal during interactive post-processing session. Displays are intended as a visual aid for interpreting the results only. Hard copy printout of the results on the screen may be taken by pressing 'PrtSc' key.

DEFAULTS

In order to minimize the input data requirements, the pre- and post-processing routines work on a default procedure. Unless a particular parameter is defined, it assumes a pre-assigned value or its earlier defined value.

INTERACTIVE HELP

The on-line input of commands and the logical operation of pre- and post-processing modules make it well suited to interactive session. A detailed interactive help system is built into the pre- and post-processor as an aid to interactive usage. The system is self-documented and gives guidance for further interactive help. The basic help commands are:

'docu, commands'	:	gives briefly all the commands available with the pre- and post-processor and their description,
'docu, proceed'	:	instructs the user how to proceed, *ie*, how to carry out pre-processing stepwise (available in pre-processing only), and
'docu, command name'	:	gives the help in detail on the particular command for which help is sought.

ILLUSTRATIVE EXAMPLE

In order to show the versatility of the pre- and post-processors, an example of two bays, three-storeyed asymmetrical frame with storey height of 3.5 m and bay widths of 4.0 m and 5.0 m respectively, subjected to superimposed load of 3500 kg/m run and nodal lateral loads of 1000 kg at the three nodes has been taken as an illustrative example. The various commands used for preparing the input file for analysis during the pre-processing session are given in Appendix III. The deformed shape of the frame, the bending moment and shear force diagrams as obtained from the post-processor are shown in Figs 1 to 3, respectively.

FIGURE 1
DEFORMED SHAPE OF 2D FRAME

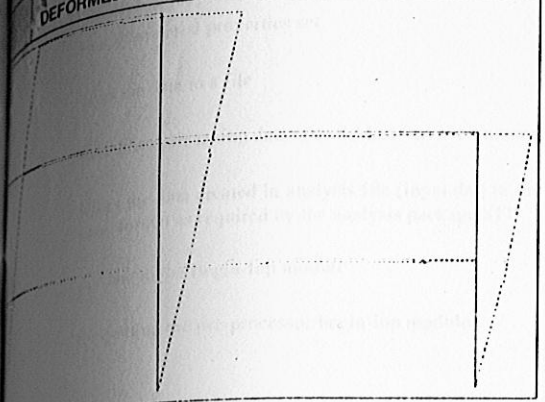
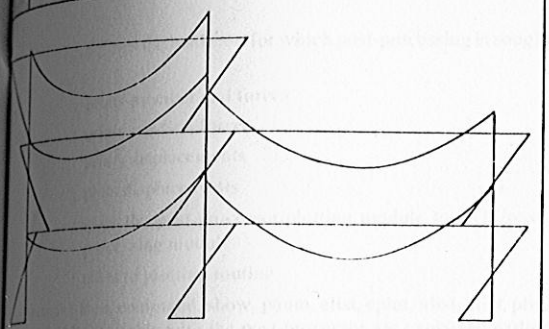


FIGURE 2
BENDING MOMENT DIAGRAM OF 2D FRAME



NCLUSION

- and post-processors greatly improve the capability of package in terms of individual's effort and computer time are of immense help to the user. Also, the conventional cedure of creating files has its own limitations and the user get away with it with the aid of pre- and post-processors.

e pre- and post-processors dealt with in this paper have n developed specifically for the matrix structural analysis kage, already in use at Central Building Research Institute d elsewhere. The pre-processor prepares the input data of plicated problems free of errors, and without any special wledge of the analysis package with minimum time and rt. Post-processor helps in giving the results in the desired m. The deformed shape of the structure and different force grams (axial force/shear force/bending moment) provide a ly comprehensive picture about structure's response der a particular loading condition and better appreciation the stress configuration.

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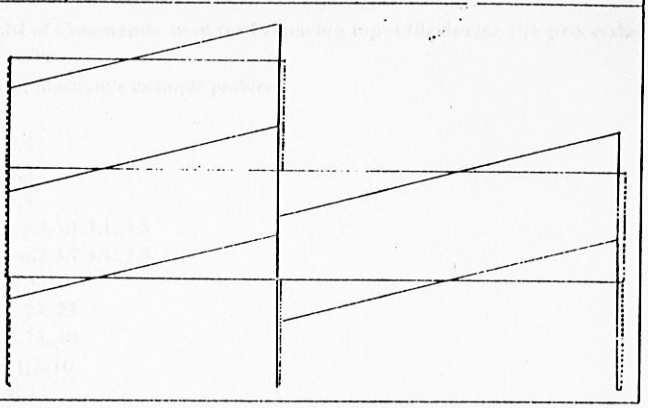
FERENCE

'Instruction Manual of Matrix Structural Analysis Program.' *CBRI, Roorkee* (Internal Publication), 1992.

FIGURE 3
SHEAR FORCE DIAGRAM OF 2D FRAME



APPENDIX I

List of Commands Available in Pre-processing Module

docu, command	: lists all the commands available
docu, proc	: lists the various steps involved in pre-processing
prep	: takes to the pre-processing module
inp	: reads input from a file
title	: defines title of the problem
show	: colour on/off
n	: creates node
ngen	: generates nodes
nlist	: lists nodes
ndel	: deletes nodes
nsel	: selects nodes
nall	: reselects all the earlier defined nodes
nplot	: plots nodes
e	: creates elements
egen	: generates elements
emod	: modifies the nodal connectivity of element
elist	: lists element
edel	: deletes elements
pnum	: draws the element no/node no in eplot/nplot
eplot	: plots elements
esel	: selects the elements
eall	: reselects all the earlier defined elements
real	: defines real properties set
mat	: defines material properties set
d	: generates boundary conditions with specified displacement
ddel	: deletes boundary conditions
dlist	: lists boundary conditions
pbc	: plots boundary conditions
ltitle	: defines load case title
f	: generates nodal loads
fdel	: deletes nodal loads
flist	: lists nodal loads
ppl	: generates point loads on members
pdl	: generates distributed loads on members
pdel	: deletes all member loads (point & distributed loads)
plist	: lists member loads (point & distributed loads)
lwrite	: writes load case data to a file (f23.dat)
ex	: defines modulus of elasticity
gx	: defines shear modulus
r	: defines real properties
kan	: defines analysis type

: lists all real properties set

: lists all material properties set

: saves the data to a file

: starts afresh by taking data upto the last 'save' command

: writes the data created in analysis file (input.dat) in the same format as required by the analysis package SFP

: to come to the Begin-Inp module

: for quitting the pre-processor/begin-inp module

PENDIX II

Commands Available in Post-processing Module

: defines the load case for which post-processing is sought

: prints member end forces

: prints reaction forces

: prints displacements

: plots displacements

: quits the post-processor/plotting module to DOS/post-processing module

: takes to plotting routine

er commands (docu, command, show, pnum, elist, eplot, nlist, dlist, pbc, esel, nall, eall) available with the post-processor are explained earlier ppendix I.

llowing are the commands available with plot routine

: plots bending moment/axial force/shear force diagram

ther commands available in plot routine are docu, esel, nall, eall, nplot, t, pbc, and show.

APPENDIX III

List of Commands used for Preparing Input file during Pre-processing Session

```
title, illustrative example problem
n,1
n,2,4
n,3,5
n,3,9
ngen,3,3,1,3,1,,3,5
ngen,2,3,7,8,1,,3,5
kan,3,0,0
r,1,,23,,23
r,2,,23,,40
ex,1,2e10
real,1
e,1,4
e,2,5
e,3,6
e,4,7
e,5,8
e,6,9
e,7,10
e,8,11
real,2
e,4,5
e,5,6
egen,2,3,9,10,1,2
e,10,11
ltitle, nodal loads and distributed loads on members
f,4,fx,1000,10,3
d,1,all,111,,3,1
pdl,9,3500,3500, 0,4,,,13,2
pdl,10,3500,3500,0,5,,,12,2
lwrite
afwr
eof
```