ABI-GEN
for
Segmentally Constructed Bridges and Frames

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1.1 INTRODUCTION

ADAPT-GEN is a computer program for the analysis and design of prestressed or nonprestressed concrete frames, during the construction phase, or when complete. It is based on a general finite element engine (ADAPT-ABI) with specific provisions for concrete material, prestressing, and composite construction.

ADAPT-GEN adds ease of modeling, and post-processing for analysis and design of real structures to its basic module (engine) ABI. This software is tailored to be a powerful production tool for analysis and design of frames, either in building construction or in bridges.

The principal features of ADAPT-ABI are:

1. Addition of an enhanced post-construction analysis capability, with options for load combination and envelope extraction;
2. Ability to re-define and refer to the structural system in terms of the familiar concepts of frame subdivision into “levels”, “spans”, “columns”, as opposed to nodes and elements;
3. Provisions for skipping (patterning) of loading to maximize the effects of load;
4. Extraction of hyperstatic (secondary) actions due to prestressing, and the option to combine these with other actions to arrive at design actions; and
5. Extraction of actions and deformations due to long-term effects of creep and shrinkage; extraction of actions due to prestressing.

1.2 PRE-. AND POST-CONSTRUCTION PHASES

1.2.1 Outline

Consider Figure 1.2-1. It shows the construction sequence of a typical frame of a parking structures with split levels. To demonstrate the concept, only two intermediate construction conditions, stages 1 and 2, (Figure 1.2-1(a) and (b)) are illustrated. If required, the construction can be broken down into additional intermediary stages. The completed frame is shown in Figure 1.2-1(c).

During the construction phase, the support condition, the shoring, and the construction loading apply. After the frame is placed in service, other loadings, such as the in-service live loads would also apply. The long-term design for serviceability and strength of the completed frame is typically calculated at a time when the frame is aged for two or more years. At this time, the time-dependent long-term effects are deemed to have essentially settled.

Based on the foregoing, the software conducts the analysis in two stages; namely:

A. construction phase, or initial phase, and
B. post-construction, or in-service condition.
The strength limit state condition is a scenario of the post-construction stage. The separation between the two stages is made by the user. In the input data, the user enters a command (CAPTURE STATUS) to effect demarcation between the two stages.
of pre- and post-construction. Details of this operation are given in Chapter 3 of the manual.

1.2.2 Pre-Capture Condition (Construction Phase)

At pre-capture phase, the structure is constructed, assembled, or dismantled, with essentially all the features of the basic ABI engine. For details refer to ADAPT-ABI Program Manual. At this stage, frame parts can be added or deleted. Shoring, or other types of support can be introduced or removed. Tendons can be stressed or de-stressed. The behavior of the in-construction frame is time-dependent, with due allowance to creep and shrinkage of concrete, aging of concrete, relaxation in pre-stressing. The frame response is also dependent on the load and stress history of the frame.

No specific time lapse is associated with the construction (pre-capture) phase. The construction stage can be extended in time, until, in the opinion of the user, the in-service condition of the frame is reached. This time lapse can be several years. The actual construction period itself can be short - expressed in terms of days. But a lapse of time of the order of years may be called for, to allow for the remaining changes in the long-term effects to become negligible.

ADAPT-GEN has the capability to faithfully model and assemble a frame during the pre-capture stage. For example, the tendon layout shown in Figure 1.2-2 for the beam at split level of a parking structure can be specified exactly as is illustrated. Tendon layout and stressing will be as required for construction. The stressing can be phased with construction of the beam. Other levels will be stressed independently at their respective due times.

1.2.3 Post-Capture (In-Service Condition)

At in-service stage, the time element is disregarded. For example, the live loading, wind or seismic loading, or any other loading specified at this stage, is considered to be applied instantaneously.

Many loading cases can be specified for the post-construction phase. For each loading, the software obtains an independent solution, as if that loading were applied alone. Unlike the preconstruction phase, the load and stress history of the structure is not retained. Hence, each solution is independent. As a result, pattern loading for the post-construction phase becomes possible. If requested by the user, the software obtains several solutions for a given loading, each with the loading placed at a different location. The results of the individual loading cases are then combined into an envelope of maxima of actions and displacements.

Solutions from different loading cases can be combined, each with a factor specified by the user.
1.3 STRUCTURE

ADAPT-GEN has the ability to view the structure as a system of levels, consisting of spans, and column grid lines, consisting of individual columns. Loading can be specified in relation to spans and columns, as opposed to nodes and elements. The results of the analysis can be organized for the display and the tabulated hard-copy in terms of spans and columns. These features bring the analysis and the output close to the user’s intuitive orientation to modeling and computational procedure for the frame.

A frame prototype, such as shown in Figure 1.2-1(c) is first modeled into a structural system (Figure 1.3-1(a)), in which centerline dimensions and boundary conditions, as well as assumptions relating to the nature of connection of members are fully defined. For example in the structural modeling illustrated, the connection between the upper end of outer columns to the beams is assumed hinged. This structural model is discretized into nodes and elements for a finite element analysis (ABI) in the conventional manner, as described in ABI.

In addition and parallel to the finite element discretization, in ADAPT-GEN the frame model can be redefined into columns lines, levels and spans, such as SPAN1 in level BEAM1 in Figure 1.3-1(b). Loading and output can be expressed in terms of the redefined structure. Details of the definition and its features are given in Chapter 2.
FIGURE 1.3-1

(a) MODEL FOR FRAME DISCRETIZATION

(b) STRUCTURAL DEFINITION

DISCRETIZATION AND STRUCTURAL DESIGN MODELS
2.1 GENERAL

This chapter describes the three primary features of ADAPT-GEN. These are:

1. Definition of a frame as a structure in terms of spans and columns;
2. Loading pattern, skipping of loads;
3. Load combinations and envelope extraction;
4. Determination of hyperstatic (secondary) actions and displacements due to prestressing.

2.2 DEFINITION OF STRUCTURE

A part, or the entire, frame being analyzed can be defined as a structure concurrent with frame’s discretization for the finite element analysis. The concurrent definition of the frame as a structure does neither change the solution procedure, nor does it affect the results. Rather, it groups the input and output data in a more recognizable and manageable format for the user. Also, it can reduce the volume of unwanted output. A finite element analysis, of which ADAPT-GEN is one, generally requires a lengthy input and results in a voluminous output. A pre-. and post-processor, such as ADAPT-GEN, can significantly reduce the input generation, and tailor the output to critical information of interest to the user.

Internally, the frame is treated in terms of nodes and elements of the finite element discretization. Externally, at the level of user interface, the frame can be viewed consisting of column grids, levels, columns, and spans. These are defined and selected by the user.

A general hypothetical plane frame is selected for the illustration of the concept (Figure 2.2-1). The frame is viewed as a matrix of intersecting lines. The lines with vertical or near vertical orientation are referred to as GRID lines. The frame shown has five grid lines, marked: A, B, C, D, and E. The selection of identification letter or name for the grid lines is arbitrary. The somewhat horizontal lines are called LEVELS. The frame has a total of seven levels. The levels are identified as: ABL_26, Lev_B, Lev_3, 23L, MID_LEV, DECK, ROOF. Again, the identification is arbitrary, within the limits of the name selection outlined in Chapter 3.

The grids are considered to consist of columns. A column is a region generally intercepted by two adjacent levels. For example, GRID C has 6 natural columns. The first column is between the support and level ABL_26. The last column is the region above the ROOF level. If need be, a column can be broken into several parts, each regarded as an individual column, in which case the sub-columns would be not intercepted by two adjacent levels.
Spans are regions of levels generally bounded by two adjacent grid lines. Cantilevers are also considered as spans. For example, level LEV_3 has five spans, including the cantilever beyond grid line E.

In summary, a breakdown option for the frame shown in Figure 2.2-1 is:

5 Grids
7 Levels
Level ABL_26 has 3 spans
Level LEV_B has 3 spans

ELEVATION OF A FRAME
In the preceding example, the entire frame is subdivided into grids and levels. If the focus of the analysis is on a particular region of the frame, only that region of the frame need be defined as a structure. By limiting the definition to only one region of the frame, the input of loading and the output can be trimmed, with focus on the region of interest.

Commonly, a span, or a column, is regarded as a region between two supports, or a cantilever. But, in ADAPT-GEN this limitation is not adhered to. A span is a region in the frame which is of particular interest to the user. For example, the single span simple support beam of Figure 2.2-2(a) is regarded as consisting of two levels, namely: LEV_1 and LEV_2. Level LEV_1 is viewed to have two regions, region SPAN_1 and region SPAN_2. The subdivision of a frame into levels and spans is not related to its discretization into elements and nodes for the finite element analysis. The only constraint is that, spans, or columns must start and terminate at a node (Figure 2.2-2(b)). For example, SPAN_2 of LEV_1 starts at node 5 and terminates at node 9.

2.3 LOAD PATTERN; ENVELOPE

The loading can be patterned (skipped) to obtain maxima and minima of displacements and actions. In skipping the load, each span is considered either loaded, or unloaded. The example shown in Figure 2.3-1 illustrates the concept. The example shows two beams, a three-span beam (Figure 2.3-1(a)) and a single span beam (Figure 2.3-1(b)). In terminology of ADAPT-GEN both beams may be defined to consist of three SPANS, or three regions. A possible pattern loading is defined in Figures 2.3-1(d) through, (f), where each SPAN is loaded while the others are unloaded. This can simulate a moving load. The three pattern loading components result in a bending moment envelope in the continuous beam such as shown in Figure 2.3-1(g) or, (h), for the single beam and the three-span beams respectively.

Note that in the context of pattern loading, the primary significance of defining a SPAN in ADAPT-GEN is to delineate the region over which loading either is active, or is absent.

The outcome of a pattern loading is an envelope, such as shown in Figure 2.3-1(g) and (h). Individual loading cases are computed, saved and can be accessed by the interested user, but are not included as part of the regular output.

For determination of actions due to moving loads in bridge structures, it is recommended to use the “moving load” module of ADAPT-ABI.

2.4 LOAD COMBINATION

The software has the capability of combining the results of individual load cases, each with a factor defined by the user.
ADAPT - PROGRAM DESCRIPTION

(a) BEAM ELEVATION

(b) BEAM DISCRETIZATION

BEAM ON TWO SUPPORTS

FIGURE 2.2-2
2.5 HYPERSTATIC ACTIONS DUE TO PRESTRESSING

ADAPT-GEN extracts the hyperstatic (secondary) actions and displacements due to prestressing. The hyperstatic actions are treated as a loading case. They can be combined with other loading cases with a multiplying factor defined by the user.

![Beam on Four Supports](image1)

(a) BEAM ON FOUR SUPPORTS

![Beam on Two Supports](image2)

(b) BEAM ON TWO SUPPORTS

![Level and Span Definition](image3)

(c) LEVEL AND SPAN DEFINITION

Pattern 1

Pattern 2

Pattern 3

(d) (e) (f)

BEAMS UNDER PATTERN LOADING

FIGURE 2.3-1
2.6 PRESTRESSING ACTIONS

The program determines the actions and displacements in the structure due to the prestressing forces. In doing so, the program accounts for the fact that prestressing may have been applied at different times and at different stages of construction. Further, there may have been stress losses, due to other reasons apart from stress relaxation. In other words, the actions due to prestressing are determined with full recognition and implementation of the loading and construction history of the structure.

2.7 LONG-TERM LOSSES

The solutions from the basic module of the program ABI (Basic) allow for and include the influence of the long-term effects using a rigorous formulation. As a result, in principle, there is no need to
calculate the long-term effects separately. However, some bridge design codes, such as AASHTO require that these effects, also can be estimated independently and combined with other load effects using a different load factor for each. For this reason, and also to serve the academia, ADAPT-Gen extracts the actions and displacements due to long term effects of creep and shrinkage as an independent set of results. Losses in prestressing are lumped into the prestressing solution. Influence of aging of concrete is included in the actions due to dead load of the structure.
3.1 OVERVIEW

ADAPT-GEN software is the extension of the special purpose software ADAPT-ABI. It is tailored to structural design of frames of both simple and complex geometry. Details of input generation of ADAPT-ABI are given in ABI’s manual. This manual is a companion to ADAPT-ABI manual. In this manual, the input description is limited to commands which are specific to data generation and ADAPT-GEN, with minimal comments on other aspects of the software. For a complete analysis, the two manuals must be used together.

3.1.1 Capabilities

This module features three principal capabilities beyond the basic module, ADAPT-ABI. One is the visualization and treatment of the frame in terms of a structure, consisting of levels, spans, column lines and column. Likewise, it offers the option of defining the loading in terms of spans and columns, as opposed to nodes and elements. The second feature is the capability of load combination and extraction of envelopes for maxima of displacement and actions. The third feature is the extraction of prestressing, hyperstatic actions due to prestressing, and long-term effects each as a distinct solution, either to be used alone or in combination with other solutions.

Commands related to the definition of the structure are grouped together under the command STRUCTURE DEFINITION. The commands for loading associated to load combination and extraction of envelopes are grouped together after CAPTURE STATUS command.

A sample input in Section 3.3 illustrates the use of the commands specific to this module. Where elucidating, the commands of this module are printed in bold font, in order to differentiate them from the commands of the basic module.

3.1.2 Preparation of Input Data

As in the basic module, input data is fed to the program through an input (ASCII) file. All input takes the form of commands consisting of one or more keywords, followed by optional numerical data required for the execution of the command. The actions and the data requirements of the commands are summarized in the following pages. All keywords must be typed in full as they appear in this manual. Mis-spelled words result in error. In most cases the errors are detected by the software’s data verification module.

All numerical data are entered in the following free field form:

\[ n_1, n_2, n_3, \ldots \quad A=a_1, a_2, a_3, \ldots \quad B=b_1, b_2, b_3, \ldots \]

where, \(n_i, a_i,\) and, \(b_i,\) represent input data and the character pairs, \(A=,\) and, \(B=,\) are identifiers, specified in the input manual, for the data list which follows. Items in a data list must be separated by a single comma or by one or more blanks. If a numerical data list without identification, such as \(n_1, n_2, n_3, \ldots\) above, is required it must
be located as the first data list on the line. A data list of the form $B=b_1,b_2,b_3,...$ may be in any order or location on the line.

Simple arithmetical statements are possible when entering floating point real numbers. This can clarify the meanings of some data. For example, the following forms of data can be entered:

$$E=29600*144 \quad C=200*12+3.5, \quad 400/12, \quad 10+20/5-2$$

These arithmetical statements are evaluated from left to right without operator hierarchy. The statement $10+20/5-2$ is evaluated as $((10+20)/5)-2$. Blank spaces within arithmetical statements are not allowed.

When a loading case must be multiplied by a coefficient, it is essential to use the multiplication symbol, $\ast$.

$$1.4\ast SDL+1.7\ast LL+1\ast PH$$

This example means combine a loading case consisting of 1.4 times the, $SDL$, loading, 1.7 times the, $LL$, loading and 1 times the loading designated by, $PH$ (hyperstatic actions due to prestressing).

The command interpreter in the program recognizes several special characters used to delimit multiple command lines on one physical line, continuation of a command line on the next physical line, and comments to be ignored by the command interpreter.

The exclamation mark is a special character used to delimit several command lines provided on one physical line. The data to the right of an exclamation point are not considered to be part of the current command line, and are instead considered as the next command line. Any number of command lines may be input on one physical input line by separating them with this character.

The backslash is a special character used for continuation of a command on the next physical line. All data to the right of the backslash are ignored, and the following input line is interpreted as a continuation of the first line. This option allows a maximum of 160 characters to be entered as one line of data.

The semicolon is a special character used to delimit comments in the input stream. All characters to the right of the semicolon up to the end of the line are ignored by the program. If the semicolon is located in the first column in a command line, the entire command line is ignored.
3.2 COMMAND SUMMARY

3.2.1 Natural Sequence of Commands

The following represents the sequence of commands for most common problems. The commands highlighted are specific to ADAPT-GEN, and will be expounded in this Chapter. The remainder of the commands are explained in ADAPT-ABI manual.

START
TITLE
UNITS
CONCRETE PARAMETERS

MESH INPUT
    NODES

SEQUENCE

CONCRETE PROPERTIES
MILD STEEL PROPERTIES
SECTION PROPERTIES
OFFSET DATA
ELEMENTS
    FRAME
    SPRINGS

PRESTRESSING STEEL
TENDON GEOMETRY

TRAVELERS
MESH COMPLETE

STRUCTURE DEFINITION
    GRIDS n LEVELS m
    GRID ######
    COLUMN
    LEVEL ######
    SPAN
STRUCTURE COMPLETE

SET

CHANGE STRUCTURE
    BUILD (Frame Element)
    RESTRAINTS

    REMOVE (Element)
    STRESS (Tendon)
    DE-STRESS (Tendon)
    MOVE (Traveler)
CHANGE COMPLETE
CAMBER INITIAL
LOADING

SOLVE
OUTPUT
CAMBER DESIGN

CAPTURE STATUS
LOADING #######
   DEAD LOAD
SOLVE
OUTPUT

LOADING #######
   PRESTRESSING
SOLVE
OUTPUT

LOADING #######
   LONG TERM
SOLVE
OUTPUT

LOADING #######
   GENERIC
   STRUCTURE
   LEVEL
   GRID
SOLVE
OUTPUT

LOADING #######
   PATTERN
   LEVEL
   GRID
   SKIP
   LEVEL
   GRID
   SKIP
   .....  
   .....  
SOLVE
OUTPUT

COMBINATIONS
   COMBINATION #######
OUTPUT
   ENVELOPE #######
      ?,?,?,?
OUTPUT

STOP
### 3.2.2 Summary of Commands

The following brief descriptions of each command and its input data requirements are intended as a summary of the software’s command syntax and as a quick reference guide for the experienced user. The highlighted commands are specific to ADAPT-GEN. Detailed descriptions of the highlighted commands and the meaning of all data are provided further on, in this manual. Sample input for a simple frame is included in this chapter for illustration.

<table>
<thead>
<tr>
<th>COMMAND SUMMARY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Initialization Input:</strong></td>
<td></td>
</tr>
<tr>
<td>START</td>
<td>Start interpreting new input data</td>
</tr>
<tr>
<td>START R=1</td>
<td>Start interpreting data for a program re-run</td>
</tr>
<tr>
<td>TITLE N=?</td>
<td>Print N lines of title</td>
</tr>
<tr>
<td>UNITS U=?</td>
<td>Set input/output units</td>
</tr>
<tr>
<td>ACTIVATE EXTRACT</td>
<td>Extract dead load, prestressing, and long-term effects.</td>
</tr>
<tr>
<td>CONCRETE PARAMETERS N=?</td>
<td>Number of concrete materials used followed by the modeling scheme used for concrete's creep and shrinkage</td>
</tr>
<tr>
<td><strong>Frame Definition Input:</strong></td>
<td></td>
</tr>
<tr>
<td>MESH INPUT</td>
<td>Start definition of structural system</td>
</tr>
<tr>
<td>NODES</td>
<td>Input node coordinates</td>
</tr>
<tr>
<td>SEQUENCE</td>
<td>Optional input for sequence of degrees of freedom for solution optimization</td>
</tr>
<tr>
<td>CONCRETE PROPERTIES</td>
<td>Input concrete material properties; strength; time dependent parameters; material model type</td>
</tr>
<tr>
<td>MILD STEEL PROPERTIES</td>
<td>Input mild steel properties and its amount in concrete used</td>
</tr>
<tr>
<td>SECTION PROPERTIES</td>
<td>Input cross section properties or geometry</td>
</tr>
<tr>
<td>OFFSET DATA</td>
<td>Input distance between natural frame nodes and analysis nodes.</td>
</tr>
<tr>
<td>ELEMENTS</td>
<td>Input total number of elements in the complete structure</td>
</tr>
<tr>
<td>FRAME</td>
<td>Input elements of the structural concrete frame</td>
</tr>
<tr>
<td>SPRINGS</td>
<td>Input springs and their stiffnesses</td>
</tr>
<tr>
<td>PRESTRESSING STEEL</td>
<td>Input prestressing steel properties</td>
</tr>
<tr>
<td>TENDON GEOMETRY</td>
<td>Define tendon numbers and geometry of each in the structure</td>
</tr>
</tbody>
</table>
TRAVELERS

MESH COMPLETE

Define traveling formwork

Signals end of structure definition

**Structure Definition Input:**

STRUCTURE DEFINITION

Signals start of structure definition

GRIDS n LEVELS m

There are, n, column lines and, m, levels

GRID ######

Start of definition of column line ######

COLUMN n

Start of definition of column, n

LEVEL ######

Start of definition of level ######

SPAN n

Start of definition of span, n

STRUCTURE COMPLETE

End of structure definition

**Set Ambient Conditions:**

SET

Define ambient conditions for the solution; such as day, temperature and solution technique parameters

**Construction Operations:**

CHANGE FRAME

Start construction operations for this step

BUILD

Install frame and spring elements

RESTRAINTS

Change or define boundary conditions

(Blank line in input)

REMOVE

Remove frame, spring, slave and hinge elements

STRESS

Stress tendons

DE-STRESS

Stress again (remove) previously stressed tendons

MOVE

Move traveler to new destination nodes

CHANGE COMPLETE

End construction operations for this step

**External Loading Command:**

LOADING

Specify load increment which can consist of nodal loads, nodal displacements, and element temperatures

**Initialize Camber Computation:**

CAMBER INITIAL

Assume current displacements as datum for camber computations

**Solution Command:**

SOLVE

Solve the current structure
Post Construction Command:

CAPTURE STATUS
Indicates completion of construction and termination of time dependency

Post Construction Loading:

LOADING #######
Header for Loading case #######

DEAD LOAD
Obtains solution due to dead loading only

PRESTRESSING
Obtains solution due to prestressing and hyperstatic actions

LONG TERM
Obtains solution due to long-term effects of creep and shrinkage

GENERIC
Loading specified in terms of nodes and elements

STRUCTURE
Loading specified in terms of spans and columns

LEVEL #######
Header for loading specification on level #######

GRID #######
Header for loading specification on column line #######

PATTERN
Indicates that following load is to be skipped

SKIP
Indicates start of skip pattern table

SOLVE
Solve for current loading

OUTPUT
Output the solution for graphical view and tabulated report

Load Combination Commands:

COMBINATIONS
Start of combination commands

COMBINATION n
Header for combination, n

ENVELOPE #######
Header and identification for envelope subcommand

Output Commands:

OUTPUT
Output total structure response

Problem Termination Command:

STOP
Stop execution, save for restart

Output Commands:

OUTPUT
Output total structure response

CAMBER DESIGN
Output displacements to be adjusted for camber control
3.3 SAMPLE INPUT FOR A NON-PRESTRESSED FRAME

3.3.1 Description of the Frame

The following is a sample input for a simple non-prestressed frame (Figure 3.3-1) with uniform rectangular cross-section subject to the following loading.

A. Selfweight
B. Uniform live load on the spans
   \[ q_1 = 10 \text{ lb/in} \]
   \[ q_2 = 8 \text{ lb/in} \]
C. Concentrated load at midpoint of level 3rd_lvl
   \[ P_1 = 10,000 \text{ lb} \]
D. Horizontal loads at column/span joints as shown
   \[ P_2 = 10,000 \text{ lb} \]
   \[ P_3 = 5,000 \text{ lb} \]

To further simplify the example, creep, shrinkage, and aging of concrete are suppressed. Also, prestressing is excluded. The purpose of the example is to illustrate the definition of the structure and load combinations. Comprehensive examples, illustrating other features, are given in Chapter 5 of this manual.

The example defines the frame as having two levels, and two column grids, each consisting of two columns.
FIGURE 3.3-1

TWO STORY RIGID FRAME
The loading cases are:

A. Selfweight (designated as Dead)
B. Live loading (designated as Live) consisting of the uniform loads on spans and the concentrated loading $P_1$, skipped to maximize actions.
B. Lateral loads $P_2$, and $P_3$, (designated as Lat)

The Load combinations are:

A. (dead load) + $1.7 \times$ (maxima of live loading)
B. (dead load) + $1.43 \times$ (lateral loading)
C. (dead load) + $1.43 \times$ (maxima of live load) + $1.43 \times$ (lateral)

The finite element discretization of the frame is shown in Figure 3.3-2.
3.3.2 Input File

;============================================================================
;    ADAPT-BRIDGE-INCREMENTAL  ABI  SOFTWARE MANUAL EXAMPLES
;============================================================================
;    name of this file: Gen-Ex31.inp

START
TITLE N=2
    TWO STORY FRAME WITH CONCENTRATED
    AND LATERAL LOADS APPLIED

UNITS U=USA
ACTIVATE EXTRACT
CONCRETE PARAMETERS N=1 ;SUPPRESS AGING EFFECT
    1 M=ACI  a=0   b=1

MESH INPUT
NODES N=16
    1 X=0   Y=0   !  5 X=0   Y=240 G=1,5
    6 X=384 Y=0   ! 10 X=384 Y=240 G=6,10
   11 X=96  Y=120 ! 13 X=288 Y=120 G=11,13
   14 X=96  Y=240 ! 16 X=288 Y=240 G=14,16

CONCRETE PROPERTIES N=1 ; NO CREEP, NO SHRINKAGE
    1 Fpc=5000  Cr=0.0  Sh=0.0  W=150/1728
MILD STEEL PROPERTIES N=1
    1 Es=29000000  P=0.00
SECTION PROPERTIES N=2
    1 D=16 B=14   ;COLUMN PROPERTIES
    2 D=23 B=11   ;BEAM PROPERTIES
ELEMENTS N=16
FRAME N=16
    1, 1, 2 C=1 X=1 St=1 Day=1 G=1,4,1,1,1
    5, 6, 7 C=1 X=1 St=1 Day=1 G=5,8,1,1,1
    9, 3,11 C=1 X=2 St=1 Day=1
   12,13, 8 C=1 X=2 St=1 Day=1
   13, 5,14 C=1 X=2 St=1 Day=1
   16,16,10 C=1 X=2 St=1 Day=1
  10,11,12 C=1 X=2 St=1 Day=1 G=10,11,1,1,1
  14,14,15 C=1 X=2 St=1 Day=1 G=14,15,1,1,1

MESH COMPLETE

;Defining the frame structure, specifying columns and spans
STRUCTURE DEFINITION
GRIDS 2 LEVELS 2
GRID A1
    COLUMN 1 LIST=1,2
    COLUMN 2   E=3,4,1
GRID A2
    COLUMN 1   E=5,6,1
    COLUMN 2 LIST=7,8
LEVEL 2ndLV
    SPAN 1   E=9,12,1
LEVEL 3rdLV
  SPAN 1 LIST=13,14,15,16
STRUCTURE COMPLETE

;Start building the frame structure elements
CHANGE STRUCTURE
  BUILD N=1,16,1
  RESTRAINTS
    1 R=1,1,1
    6 R=1,1,1

CHANGE COMPLETE
SOLVE Day=28   !OUTPUT
SOLVE Day=100  !OUTPUT

;Start of structure loading
CAPTURE STATUS
  LOADING Dead      ;selfweight
  DEAD LOAD

SOLVE
OUTPUT

LOADING Live       ;concentrated and uniform live load
PATTERN
  LEVEL 2ndLV
    SPAN 1
    UNIFORM F=0,-10
  LEVEL 3rdLV
    SPAN 1
    UNIFORM F=0,-8
    CONCENTRATED F=0,-10000,0 AT N=15
SKIP
  LEVEL 2ndLV SPANS 1
  LEVEL 3rdLV SPANS 0
SKIP
  LEVEL 2ndLV SPANS 0
  LEVEL 3rdLV SPANS 1
SKIP
  LEVEL 2ndLV SPANS 1
  LEVEL 3rdLV SPANS 1

SOLVE
OUTPUT

LOADING Lat        ;concentrated lateral live load
STRUCTURE
  GRID A1
    COLUMN 2
    CONCENTRATED F=10000,0,0 AT N=5
  GRID A1
    COLUMN 1
    CONCENTRATED F= 5000,0,0 AT N=3

SOLVE
OUTPUT
COMBINATIONS
COMBINATION A ;dead + live load
   1.4*Dead+1.7*Live
OUTPUT ;output here is optional

COMBINATION B ;dead + lateral
   0.9*Dead+1.43*Lat
COMBINATION C ;dead + live + lateral
   1.0*Dead+1.43*Live+1.43*Lat
OUTPUT
ENVELOPE D
   A,B,C ;envelop load combinations A, B, & C
OUTPUT
STOP

3.4 DETAILED DESCRIPTION OF COMMAND SYNTAX

The detailed syntax of each command and a description of its use, actions and output are described below. The commands are organized alphabetically. An approximate order in which the commands normally will be found in a typical input file is given in Section 3.2.1. Most commands are optional, and must not be used unless required for the structure under analysis (i.e. a command such as, GENERIC, must not be used if no loading is defined using the GENERIC format).

The optional parts of the syntax line are enclosed in square brackets [...]. For example, [ALL] when used would refer to all the relevant spans or columns; if left out, the command refers to the spans mentioned on the command line only.

In the Explanation part of the command, default values for input quantities, where implemented in the program, are indicated by [?], with the value of the default entered within the square brackets. [pv] indicates a default value assumed to be equal to the previous value entered.

It is recommended that the first time user follows the order of commands as described in the natural sequence (Section 3.2.1), starting with the description of command STRUCTURE, in conjunction with Figure 3.3-2. A familiar user would use this section as a reference.

CAPTURE STATUS

Syntax:       CAPTURE STATUS

Explanation: This command has no arguments. It signifies the termination of the construction stage and the time dependent analysis. After this command, the frame behaves as a linear elastic structure. Loading is no longer incremental (accumulative). Displacements and actions due to each loading case will be computed based on the geometry and stiffness at the time CAPTURE STATUS command is specified. Solutions
of different loading cases can be combined to obtain envelopes or factored actions.

**COLUMN**

**Syntax:**

\[
\text{COLUMN } i \ E=l_{1},l_{2},\text{inc}
\]

or

\[
\text{COLUMN } i \ \text{LIST}=l_{1},l_{2},l_{3},...\ldots,l_{n}
\]

where,

- \(i\) = Column number
- \(l_{1}\) = Frame element number of first element in a series of elements which define the column
- \(l_{2}\) = Element number of last element in series
- \(\text{inc}\) = Element number increment
- \(l_{1},l_{2},l_{3},...,l_{n}\) = Frame element number of first element in a series of elements which define the column, followed by a sequential list of other elements, \(l_{2},l_{3}\), until the last element of series, \(l_{n}\).

**Explanation:** Each column in a **GRID** is defined by one subcommand line starting with **COLUMN** \(i\). The column number, \(i\), is a sequential integer designating the column being defined from the list of columns in a **GRID**. For example, if a grid has 5 columns, there must be five **COLUMN** subcommands, each defining one of the 5 columns of the grid.

**Example:**

(i) Refer to Figure 3.3-3(d)

```
GRID C3
  COLUMN 1 ....
  COLUMN 2 ....
  COLUMN 3 ....
```

Note that the column not highlighted as part of the structure is not listed.

(ii) Refer to Figure 3.3-3(c)

```
GRID C2
  COLUMN 1 List=....
  COLUMN 2 List=....
```
(iii) Refer to Figure 3.3-3(b)

GRID  C2
COLUMN 1  E=....
COLUMN 2  E=....
COLUMN 3  List=....

COMBINATION

Syntax:  COMBINATION ######

\[ [k1*load1] + [k2*load2] + [k3*combination1] + ...[ki*PH] \]

where,

##### = An up to six character alphanumeric string identifying the combination
k1,k2,... = Coefficients to be multiplied by the loading cases and combinations load1, load2,..., combination1,...
PH = Hyperstatic actions due to prestressing (secondary actions)

Explanation:  The combination identification, ######, will be printed at the top of its relating output.

The loading cases must all have been previously defined. The addition sign, +, can be either a positive sign, +, or a negative sign, -, for subtraction.

The optional loading [PH] refers to the hyperstatic (secondary) action of prestressing.

The prestressing load will be referred to by its user defined loading identification.

If any of the components of the combination requested has an envelope, that is to say it is obtained through a SKIP command, the combination outcome would also be an envelope.
FIGURE 3.3-3

EXAMPLES OF GRID AND LEVEL SELECTION

(a) ELEVATION OF FRAME
(b) MEMBER SELECTION
(c) MEMBER SELECTION
(d) MEMBER SELECTION
COMBINATIONS

Syntax: COMBINATIONS

Explanation: This subcommand has no argument of its own. It signifies the end of loading conditions and the start of combination of previously obtained solutions under LOADING.

The COMBINATIONS command is followed by a series of COMBINATION and ENVELOPE subcommands, each of which describe one loading combination or envelope. Refer to COMBINATION and ENVELOPE command for their syntax. An OUTPUT command following a COMBINATION or ENVELOPE subcommand will result in a print out of that combination in the user’s file, as well as a display of its results. The OUTPUT subcommand is optional. If the OUTPUT subcommand is used, the software generates a set of internal output data which would allow the combination/envelope to be displayed on the screen, and to be integrated as part of subsequent COMBINATION or ENVELOPE commands.

Example:

COMBINATIONS

  COMBINATION ######
  ..................

  OUTPUT

  COMBINATION ######
  ..................

  ; no output will be generated

  ENVELOPE ######
  ?,?,?,?

  OUTPUT

DEAD LOAD

Syntax: DEAD LOAD

Explanation: This subcommand has no argument. It generates a solution for the entire loading on the frame at the time CAPTURE STATUS was called, minus PRESTRESSING, if any, and minus LONG Term effects. The loading prior to capture status on the frame can be due to selfweight and other loading, such as superimposed loading. The rational behind this subcommand rests on the following scenario. A frame is built; prestressing is added optionally; superimposed loading, such as topping is added; lapse of time allows for creep and shrinkage to take place; the frame enters the phase of its service life - the steady state. At this time, through CAPTURE STATUS command the time is frozen. Subsequently, the frame stresses and deformation are investigated due to a combination of loading cases. One such loading case is the steady state itself, which is dead load plus prestressing, and plus long-
term effects if any. The investigation proceeds by obtaining separate solutions for
*dead loading*, *prestressing* and *long-term* effects, and then combining them.
Solutions for the loading components are extracted separately, since they will enter
the combinations with different factors.

**ENVELOPE**

**Syntax:**

```
ENVELOPE ######
[LOADINGi], [ENVELOPEi], [COMBINATIONi]
```

where,

```
####   = Any up-to-6-character alphanumeric string for identification of
         the current envelope
LOADINGi = The identification string of a previously defined loading case
ENVELOPEi = The identification string of a previously defined envelope
COMBINATIONi = The identification string of a previously defined combination
```

**Explanation:**

The identification string, ######, used for each envelope must be unique, that is to
say, it must not have been used elsewhere in data input. The software initially stores
the outcome of the envelope under a file name which incorporates the string,
####. The output, if requested, uses the same string as its header.

The ENVELOPE command scans the results of the components indicated in the
syntax, for the nodes and elements of the structure, and selects both the maxi-
mum and minimum values of displacements and actions. The command
groups the maxima and minima selected and stores them in a file for future
use by the user. If the ENVELOPE command is followed by an OUTPUT com-
mand, the results will be printed as part of the output of the problem, and will
also be available for graphical display. Otherwise, the solution remains in the
background in an internal file until it is called to be included in a future
COMBINATION, or ENVELOPE command.

It is imperative that all components listed after the ENVELOPE command have
been previously defined.

The ENVELOPE command compares the results of the components listed and
selects the largest and smallest of each item. Unlike the COMBINATIONS
command, ENVELOPE command does not scale, nor does it add the arguments
listed.
Example: COMBINATIONS

COMBINATION A
1.4*DEAD+1.7*LIVE

COMBINATION B
0.9*DEAD+1.7*EQ

COMBINATION C
1.1*DEAD+1.43*LIVE+1.43*EQ

ENVELOPE DESIGN
A, B, C

In this example, it is implicit that prior to the COMBINATIONS command, solutions for three loading cases must have been obtained. These are SDL, LIVE, and EQ. Combinations A, B, and, C, each scale and combine the respective loading according to the relationship given for each. The ENVELOPE command reviews the three combinations A, B, and C, and selects the maximum and minimum value of each for DESIGN.

GENERIC

Syntax: GENERIC

Explanation: This subcommand has no arguments. It signifies that in the lines following, the loading is specified in terms of its position with respect to a node, or element. The loading specification follows a syntax identical to ADAPT-ABI Basic LOADING command, except that no imposed nodal displacements are allowed at this stage.

The load specification under this subcommand is similar to the pre-capture stage. Note that there is a greater flexibility in some types of load definition if STRUCTURE subcommand is used. For example concentrated loads can be applied at given distances, as opposed to nodal locations (see STRUCTURE subcommand).

A summary of the load specification syntaxes applicable under GENERIC subcommand are given below:

\[ N=n_1,n_2,inc \quad F=f_x,f_y,f_{zz} \quad \text{(concentrated load)} \]
\[ L=l_1,l_2,inc \quad F=f_x,f_y \quad \text{(uniform load)} \]
\[ L=l_1,l_2,inc \quad T=t_{top},t_{bot} \quad \text{(temperature load)} \]

where,

\[ n_1 = \text{Node number of first node in a series of nodes with identical applied loading or displacements} \]
\[ n_2 = \text{Node number of last nodes in the series} \ [n_1] \]
11 = Frame element number of first element in a series of elements with the identical applied loads or identical temperatures
inc = Element or node number increment
fx = X-force, or X-force per unit Y-projected length
fy = Y-force, or Y-force per unit X-projected
fzz = Z-moment
ttop = Temperature at top fiber of cross section
tbot = Temperature at bottom fiber of cross section

For additional details, refer to ABI manual.

GRID

Syntax: GRID ######

where,

######_ = Is any alphanumeric string up to six characters, such as LINE4.

Explanation: Each grid line is identified by a user selected identification name consisting of up to six alphanumeric characters, such as 5/A. Each grid line and level should have its own unique identification. The same name may not be used for two, or more, grid or column lines. Solutions of columns within a grid are grouped together for graphical display, or hard-copy printout.

GRIDS n LEVELS

Syntax: GRIDS n LEVELS m

Explanation: It indicates that the structure envisaged is assigned to have, n, column grid lines and, m, levels. The designation is subjective. It depends on the extent of the members a user intends to investigate in detail. Either the entire frame, or portion thereof can be designated as GRID and LEVEL. Refer to Figure 3.3-3(a). It shows the elevation of a frame with three column lines, designated C1, through, C3, and four levels, L1, through, L4. The following provides several valid examples for defining part of the frame as a structure.

Example: (i) For Figure 3.3-3(a)

GRIDS 3 LEVELS 4
(ii) For Figure 3.3-3(b)

   GRIDS 2  LEVELS 1

(iii) For Figure 3.3-3(c)

   GRIDS 1  LEVELS 1

(iv) For Figure 3.3-3(d)

   GRIDS 1  LEVELS 2

In all the previous examples, a complete solution based on the entire frame and its loading will be obtained. The difference between the various options lies in the amount and organization of output. In each case, the primary graphical and hard-copy output is limited to the grid and levels defined for the structure. This will allow the user to trim the unwanted output and focus on the members of interest. However, should a question regarding the actions and displacements in members not defined as part of the structure arise, the user can refer to a set of secondary files generated by the software. In the secondary files, the entire solution is documented for detailed review. In other words, by defining a structure within the entire frame, the user does not lose the option to access the entire solution.

**LEVEL**

**Syntax:**  LEVEL  ######

where,

    ######  = Is any alphanumeric string up to six characters, such as 2LEVEL

**Explanation:** Each level line is identified by a user selected identification name consisting of up to six alphanumeric characters, such as, 3rdLev. Each grid line and level should have its own unique identification. The same name may not be used for two, or more, grid or column lines. Solutions of spans within a grid are grouped together for graphical display, or hard-copy printout.

**LOADING**

**Syntax:**  LOADING  ######

where,

    ######  = Any alphanumeric string of six or more characters used by the user to identify the loading case that is described following this command.
Explanation: The loading identification serves two purposes. (i) It will be printed at top of the respective solution in the output for ease of reference. (ii) When using load combinations, the contribution of each loading in the combination is effected by a user defined factor times the load. The load identification string used must be unique among the loading cases of each problem. Two or more loading cases can not be assigned the same identification string.

An overview of the subcommands following LOADING command is given below:

![Diagram of LOADING command structure]

A LOADING command is terminated by a SOLVE command. Note than only one of the types of loading indicated in the preceding diagram, can be included in each LOADING command. The LOADING command, followed by SOLVE command must be repeated as many times, as it is necessary to cover all the loading intended by the user.

[GENERIC] [STRUCTURE] shown in the first category indicates the options. Either one, or both, of the loading types shown in each of the square brackets, [ ], can be specified under the same loading identifications. Each loading type, such as [STRUCTURE] is described in detail in this chapter under its designated heading. A short account for definition of each loading type is given next:

GENERIC: Loading is defined in exactly the same manner as the pre-capture-status, that is to say, like in ADAPT-ABI basic module. The special feature is that loading is expressed in terms of nodes and elements. No imposed displacements are allowed at this stage.

STRUCTURE: The loading is specified in terms of spans and columns of the structure previously defined.
PRESTRESSING:
Determines the displacements and actions due to prestressing only, including hyper-
static (secondary) actions.

PATTERN:
Applies to live loading. Solutions for a number of loading combinations will be
computed, each with a different arrangement of live loading, in order to obtain the
maxima of actions and displacements at each location. For details refer to PAT-
TERN command.

LONG TERM
Syntax: LONG TERM
Explanation: The long-term loading case when invoked extracts the changes in actions and
displacements of the structure due to the delayed effects of shrinkage and creep,
and the effects of temperature change. The effects are the accumulated sum of such
changes over the life of the structure until the call of CAPTURE STATUS command.
The changes due to relaxation in prestressing are lumped with the PRESTRESSING
loading case. The impact of “aging” on the solution is grouped with DEAD LOAD
loading condition.

Note that each of these load cases must be invoked on its own, separate from the
other loads. Once the values are obtained, they can be enveloped or combined with
other loads.

Example:

```
CAPTURE STATUS

LOADING DL
   DEAD LOAD ; reserved loading case
   SOLVE
   OUTPUT

LOADING PT
   PRESTRESSING ; reserved loading case
   SOLVE
   OUTPUT

LOADING LT
   LONG TERM ; new reserved loading case
   SOLVE
   OUTPUT

LOADING POINT1
   GENERIC
```
N=3  F=0,-100,0
SOLVE
OUTPUT

COMBINATIONS
COMBINATION SELWGT ; gives a solution identical
1*DL+1*PT+1*LT ; to the last stage of
OUTPUT ; precapture

OUTPUT

Syntax: OUTPUT [ALL] [SAME] [DISPLACEMENTS] [ACTIONS] [REACTIONS] [STRESSES]

Explanation: Other options within [ ] are identical in function to the pre-capture OUTPUT command, except PRESTRESSING. The prestressing command would function only if the preceding loading is, prestressing, otherwise it would be ignored. The reason the output for prestressing is turned off for other loading conditions is that prestressing would not change for the post-capture solutions. Hence, its printout would be repetitious.

If the loading preceding the output command includes SKIP subcommand, the output would automatically generate an envelope.

OUTPUT command in conjunction with COMBINATION and ENVELOPE commands has the same syntax, and is mandatory to obtain printout of such results.

PATTERN

Syntax: PATTERN

Explanation: The PATTERN subcommand indicates that the loading followed will be placed selectively on different locations, in order to obtain the maximum and minimum values of displacements and actions at each location in the structure.

The general form of Pattern subcommand is as follows:

PATTERN
   Applied Loading
SKIP
   Skip table
SOLVE
The pattern subcommand must be followed by SKIP and SOLVE subcommands as shown in the preceding. After the subcommand pattern and before the SKIP subcommand, the loading which will be selectively applied is described. After the subcommand SKIP, the sequence in which the defined loading must be applied to various spans and columns will be specified in a user defined skip table. In the applied loading section, the entire loading which is envisaged to be considered for skipping, will be defined. It is the skip table which determines which loading must be applied where and together with which other loading.

The general sequence of loading and skip table is as follows:

```
PATTERN
  LEVEL ######
  SPAN
    CONCENTRATED
    UNIFORM
    TEMPERATURE
  GRID ######
  COLUMN
    CONCENTRATED
    UNIFORM
    TEMPERATURE
SKIP
  GRID ###### COLUMNS ? ? ? ?
    LEVEL ###### SPANS ? ? ? ?
  SKIP
  GRID ###### COLUMNS ? ? ? ?
    LEVEL ###### SPANS ? ? ? ?
.............
SOLVE
```

The applied loading is described in exactly the same manner which is outlined under STRUCTURE subcommand of loading. That is to say, the loading is defined in terms of spans and columns of levels and grids. The loading can not be specified in the generic format. PRESTRESSING, DEAD LOAD, and LONG TERM can not be specified as part of skip loading. The effect of these three types of loading on the structure can best be investigated through load COMBINATIONS command.

The skip tables describe where the loading must be applied. Each skip table starts with the subcommand SKIP. It is terminated by either the SOLVE command, or start of another SKIP table.
The general format of a skip table is as follows:

```
SKIP
  LEVEL ###### SPANS 1 0 1 0 1 0 ....
  LEVEL ###### SPANS 0 1 0 1 0 1 0 ....
;................ more levels, if needed ............
GRID ###### COLUMNS 1 1 1 1 ....
GRID ###### COLUMNS 1 1 1 1 ....
;................ more columns, if needed ............
SKIP
  LEVEL ###### SPANS 0 1 0 1 0 1 ...
...........................................................
```

A skip table is nested between two SKIP subcommands, or a SKIP subcommand and a SOLVE command. After the token SPANS, or COLUMNS, a series of, 1, and, 0, are specified. Each digit refers to one of the spans or columns, starting from span/column 1 and continuing successively until the last span. Hence, the number of digits following a SPANS, or COLUMNS token equals the number of respective spans/columns of the associated LEVEL/GRID. Only the levels and spans which are called in the table and are given an identification of, 1, are loaded. A, 0, means that the associated span, or column is not loaded. For example, SPANS 1 0 1 1, signifies that there are 4 spans on the associated level. Spans 1, 3, and 4 are loaded, span, 2, is not loaded.

**PH**

**Syntax:** PH

**Explanation:** Refers to hyperstatic (secondary) actions. It is described under subcommand PRESTRESSING.

**PRESTRESSING**

**Syntax:** PRESTRESSING

**Explanation:** This subcommand has no argument. When invoked, it generates a solution to the prestressing available at time of capture. At time of CAPTURE STATUS, the time-dependent parameters are frozen, hence, there will be no change in prestressing due to creep, shrinkage, aging of concrete, and relaxation of steel. However, due to post-capture loading there will be changes in displacement of the structure. Strictly speaking, the strains due to displacement cause a change in prestressing forces. This subcommand gives a solution which corresponds to the condition of the frame at CAPTURE STATUS time. Once invoked, it
generates a detailed set of information on prestressing forces, losses, displacements due to prestressing and hyperstatic actions (secondary actions). Changes in prestressing due to applied loading must be investigated at the pre-capture condition. At the post-capture state, regardless of when the \textit{prestressing} subcommand is called, it always yields the same solution, since time-dependency and impact of displacement of structure on prestressing are suppressed.

From the preceding, the \texttt{PRESTRESSING} subcommand generates two sets of solutions. Both sets are printed in the user’s output and are available for graphical viewing. The first set is named PT. It contains the displacements and actions (moments, shears, and axial loading) associated with the prestressing forces at the time of the capture (freezing of time-dependent parameters). The second set is named PH. It is the hyperstatic (secondary) actions due to prestressing at the time of capture. The hyperstatic actions are defined as actions generated due to post-tensioning forces in the structure, due to the structure’s resistance to displacement at the supports. The relationship between the two actions at any given location is as follows, for additional details refer to Appendix A.

\[
PH = PT - P*e
\]

where,

- \(PH\) = Refers to hyperstatic actions
- \(PT\) = Refers to the total of actions due to post-tensioning forces
- \(P\) = Prestressing force
- \(e\) = eccentricity of the prestressing force (\(P\))

It is important to note that the hyperstatic actions are computed incrementally with the progress of construction. These actions are duly adjusted as stress losses take place, and as the boundary conditions of the structure change.

For example, pre-stressing in a simply supported single span girder will not cause hyperstatic action by itself. But if the girder is then locked to other parts of the structure (made continuous), subsequent changes in prestressing, such as due to creep, will result in hyperstatic actions. Because of its incremental solution strategy, ADAPT-Gen correctly captures and reports the associated hyperstatic actions.

**SPAN**

**Syntax:**

\[
\text{SPAN } i \ E=\text{list}
\]

or

\[
\text{SPAN } i \ \text{LIST}={\text{list}}
\]
where,

\[ i \] = Span number
\[ l_1 \] = Frame element number of first element in a series of elements which define the column
\[ l_2 \] = Element number of last element in series
\[ \text{inc} \] = Element number increment
\[ l_1, l_2, l_3, \ldots, l_n \] = Frame element number of first element in a series of elements which define the span, followed by a sequential list of other elements, \( l_2, l_3, \) until the last element of series, \( l_n.\)

**Explanation:** Each span in a **LEVEL** is defined by one subcommand line starting with **SPAN** \( i \). The span number, \( i \), is a sequential integer designating the span being defined from the list of spans in a **LEVEL**. For example, if a level has 5 spans, there must be five **SPAN** subcommands, each defining one of the 5 spans of the level.

**Example:**

(i) Refer to Figure 3.3-3(d)

```
LEVEL L2
  SPAN 1
  SPAN 2
LEVEL L3
  SPAN 1
```

Note that the span not highlighted as part of the structure is not listed.

(ii) Refer to Figure 3.3-1 and Figure 3.3-2

```
LEVEL 2nd_lv
  SPAN 1  List=9,10,11,12
LEVEL 3rd_lv
  SPAN 1  E=13,16,1
```

(iii) Refer to Figure 3.3-3(c)

```
LEVEL L2
  SPAN 1  E=....
  SPAN 2  E=....
```
STOP
Syntax: STOP
Explanation: The STOP is the last command in the input data that terminates the program. Its inclusion is mandatory.

STRUCTURE
Syntax: STRUCTURE
Explanation: Signifies that the loading is specified in reference to the structural members (columns and span) as previously defined under the STRUCTURE DEFINITION command. Defining the load under STRUCTURE subcommand has the advantage that the user can specify the loads in term of spans, such as uniform load on an entire span, as opposed to loads on nodes and elements. Likewise, concentrated loads can be given at distances from the span supports compared to specification at the nodes.

The common sequence and syntax for the structural member definition for this subcommand is:

```
STRUCTURE
  LEVEL #######
    SPAN [n][l1,l2,inc][ALL]
    CONCENTRATED N=n1,n2,inc F=fx,fy,fzz \ 
      [at N=?][at x=?]
    UNIFORM [L=l1,l2,inc] F=fx,fy \ 
      [xB=?][xE=?][NB=?][NE=?]
    TEMPERATURE [L=l1,l2,inc] T=ttop,tbot
  GRID #######
    COLUMN [n][l1,l2,inc][ALL]
    CONCENTRATED N=n1,n2,inc F=fx,fy,fzz \ 
      [at N=?][at x=?]
    UNIFORM [L=l1,l2,inc] F=fx,fy \ 
      [xB=?][xE=?][NB=?][NE=?]
    TEMPERATURE [L=l1,l2,inc] T=ttop,tbot
```

In the following the syntax of each of the subcommands is described in more details.

```
Syntax: CONCENTRATED N=n1,n2,inc F=fx,fy,fzz \ 
          [at N=?][at x=?]
```

where,
n1 = Node number of first node in a series of nodes with identical applied loading
n2 = Node number of last node in the series [n1]
inc = Node number increment
fx = X-force
fy = Y-force
fzz = Z-moment
At N = Node number where loads are applied
AT x = Distance, x, measured in local coordinate along the member, where loads are applied

The local coordinate of a member are defined as the line joining the first node of the member to its last node.

Example: Refer to Figure 3.3-3

SPAN 2
CONCENTRATED F=-200,0,0 AT x=120

Note: There is a concentrated loading in the global y-direction with magnitude of -200 units acting at a distance 120 units along the length of span 2 from its beginning.

The subcommand described must be repeated as many times as necessary to describe the entire loading. In the general case, it is not practical to specify all the loading in one line.
Syntax: GRID #######
    COLUMN [n][n1,n2,inc][ALL]

Note: The syntax and load description is identical to that of span described in the preceding:

    CONCENTRATED N=n1,n2,inc F=fx,fy,fzz \[at N=?][at x=?]
    UNIFORM [L=l1,l2,inc] F=Fx,Fy [xB=?][xE=?]\[NB=?][NE=?]
    TEMPERATURE [L=l1,l2,inc] T=Ttop,Tbot

Explanation: The syntax and load specification of subcommands Concentrated, Uniform and Temperature are identical to the description given under Span subcommand.

Syntax: LEVEL #######

Explanation: Indicates that the following loading are on spans of level previously identified by the alphanumeric string, ######. The level must have been previously defined in the STRUCTURE DEFINITION command, before its spans can be loaded.

Syntax: SPAN [n][l1,l2,inc][ALL]

where,

n = Span number
l1 = Frame element number of first element in a series of nodes
l2 = Element number of last element in the series
inc = Node number increment
ALL = All spans

Examples: SPAN 2
SPAN 2,5,1
SPAN ALL

Syntax: TEMPERATURE [L=l1,l2,inc] T=Ttop,Tbot

where,

l1 = Frame element number of first element in a series of elements with identical applied loads
l2 = Element number of last element in the series
inc = Element number increment

ttop = Temperature at the top fiber of the element

tbot = Temperature at the bottom fiber of the element

**Explanation:** If \([L=l1,l2,inc] \) is omitted, the temperature specified is applied to the entire member (span, or column)

**Syntax:**

\[
\text{UNIFORM } \ [L=l1,l2,inc] \ F=fx,fy \ [xB=?][xE=?] \\
[NB=?][NE=?]
\]

where,

- \(l1\) = Frame element number of first element in a series of elements with identical applied loads
- \(l2\) = Element number of last element in the series
- \(inc\) = Element number increment
- \(fx\) = X-force per unit Y-projected length
- \(fy\) = Y-force per unit X-projected length
- \(NB\) = Node number of the beginning point of the pressure loading
- \(NE\) = Node number of the end point of pressure loading
- \(xB\) = Coordinate, x, of the beginning point of the pressure loading in local coordinates [0]
- \(xE\) = Coordinate, x, of the end point of the pressure loading in local coordinates, [length of member]

**Example:** Refer to Figure 3.3-3

```
LEVEL L1
  SPAN ALL
    UNIFORM F=-10,0
```

Note: All spans of level L1 are subject to a uniform load in the global y-direction with intensity of, -10, per unit of length

The subcommand described must be repeated as many times as necessary to describe the entire loading. In the general case, it is not practical to specify all the loading in one line.
STRUCTURE COMPLETE

Syntax: STRUCTURE COMPLETE

Explanation: The STRUCTURE COMPLETE command has no argument of its own. It signals the termination of subcommands used to define either a region, or the entire frame previously defined as a STRUCTURE DEFINITION.

STRUCTURE DEFINITION

Syntax: STRUCTURE DEFINITION

Explanation: The STRUCTURE DEFINITION command has no argument of its own, but is followed by a series of subcommands which define as a structure, either a region, or the entire, frame generated through the MESH command.

The structure definition command includes one or more subcommands nested between the two commands STRUCTURE DEFINITION and STRUCTURE COMPLETE. These commands are:

- STRUCTURE DEFINITION: starts the structure definition;
- GRIDS n LEVELS m: gives total of column and level lines;
- GRID ######: header for column line ######;
- COLUMN i: header for column, i;
- LEVEL ######: header for level ######;
- SPAN i: header for span, i;
- STRUCTURE COMPLETE: terminates the STRUCTURE DEFINITION command.
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4.1 BACKGROUND

ADAPT-GEN is a software for the analysis and design of concrete or composite plane frames with or without prestressing. It accounts for the time-dependent behavior of concrete material in shrinkage, creep, aging, as well as the time-dependent response of prestressing in stress relaxation. In addition, the software has the capability of incremental construction, or dismantling of a frame (reverse construction).

The basic formulation of the problem and the procedure for obtaining solutions are detailed in Chapter 4 of ADAPT-ABI program manual. ADAPT-ABI is the primary program module, to which ADAPT-GEN is an augmentation. In this chapter, only the features which are specific to ADAPT-GEN are presented.

4.2 FEATURES OF ADAPT-GEN

For each problem, ADAPT-GEN performs two types of analysis. The first is referred to as pre-capture and the second the post-capture. The word capture is used in relation to the command CAPTURE_STATUS in input data. When invoked, this command will freeze the lapse of time for the frame being analyzed.

4.2.1 Pre-Capture Features

The program behaves identically to ABI. The frame can be constructed, or dismantled incrementally, with or without allowance for time-dependent parameters: creep, shrinkage, aging of concrete and relaxation of prestressing. Further, the load and stress history of the structure is retained and implemented in the analysis as time and construction proceed.

4.2.2 Post-Capture Features

Once the CAPTURE_STATUS command is encountered, the software assumes the post-capture mode. In this mode, the time element is assumed frozen at the date the capture status command was called. All subsequent computations are performed without inclusion of creep, shrinkage, aging of concrete and relaxation of prestressing - if any. Existing stress and load history of the frame are abandoned. Further:

- The structure is assumed to have the configuration and the support condition of the CAPTURE_STATUS day. No change in configuration of the structure is allowed, neither for adding, nor for deleting of elements. Supports may not be added or removed.

- The stiffness of the structure is assumed to remain unchanged throughout the post-capture analysis. It is assumed to be equal to stiffness associated with the day the capture status command was called, but excluding the stiffness of prestressing tendons. The stiffness of cable stays and the stiffness of nonprestressed steel is retained. Note that in precapture condition, the stiffness
due to the extension of tendons under applied loading is included in the analysis.

- The structure is assumed to be under no loading. Selfweight is also removed.
- A linear elastic analysis is used to determine the deformation and stresses due to each added loading. Hence, the solution of each loading is independent from the prior loading on the structure. Each solution is stored separately. The
stresses and strains associated with the current loading are flushed out from the structural data prior to the analysis of a new loading case.

4.3 STRESSES IN CONCRETE; PRE-. AND POST-CAPTURE ALLOCATION OF ACTIONS AT A NODE

In the interpretation of the ABI solutions, it is important to be clear on the method used in allocating actions at a section among concrete, prestressing, and the non-prestressing reinforcement. Also, the computation of concrete stresses requires special attention.

The resultant moment, shear, and axial loading are defined as actions at a node.

4.3.1 Description

Refer to Figure 4.3-1. It shows an element, IJ, with the actions entered at node, J. In Figure 4.3-1(a) the resultant of external actions at node, J, are the moment, shear and axial loading, M, V, and N, as shown.

For pre-capture computations, the internal actions at a node are made up from contributions of the prestressing tendons, if any, and the concrete. Refer to Figure 4.3-1(b). The force, P, represents the resultant force of all tendons at node, J. For clarity, only one tendon is shown. The relationships between the resultant actions at node, J, and their constituents are:

\[ M = M_c + P_x \cdot e \]
\[ V = V_c + P_y \]
\[ N = N_c + P_x \]

Where, \( M_c \), \( V_c \), and \( N_c \), are moment, shear and axial loading contribution of concrete (plus nonprestressed reinforcement); \( P_x \) and \( P_y \) are contributions from prestressing. The contribution from pre-stressing is due to initial prestressing force with allowance for creep, shrinkage, aging of concrete, relaxation of stress in tendon, and strain at location of strand due to deformation of the structure.

At the pre-capture status stage, the actions listed for the element at a node are those associated with the concrete constituent, namely, \( M_c \), \( N_c \), and \( V_c \). Likewise, the stresses are those due to these actions acting on the section. Hence, stress due to bending is:

\[ f_{top} = M_c \cdot y_{top} / I \]
(a) PRE-CRACKING DISTRIBUTION OF STRESS

(b) LIMIT STATE FORCE ASSUMPTION

SERVICE AND STRENGTH LIMIT STATE STRESSES AT A SECTION

FIGURE 4.3-2
Where, $f_{\text{top}}$ is stress at top fiber; $y_{\text{top}}$ is distance of centroid to top fiber; and $I$ is the moment of inertia of the section. Stress at bottom fiber is obtained in a similar manner. Refer to Figure 4.3-2(a) for distribution of stress at pre-capture condition.

At post-capture stage, the actions listed for node, J, are due to forces on the entire concrete cross-section, that is to say, $M$, $N$, and $V$ in Figure 4.3-1. The actions are not broken between the tendons and the concrete cross-section. Hence for the same loading and boundary conditions, the stress obtained for concrete can be different for pre-. and post-capture conditions. The commonly performed engineering hand calculations correspond to the post-capture scheme of the software. At limit state, the stress distribution on the section is as shown in Figure 4.3-2(b).

In simple hand calculations, the contributions of tendon in resisting the action is generally disregarded. The sum of actions at this node, namely, $M_c$, $N_c$, and $V_c$, as shown in Figure 4.3-1(b).

Hence, for the post-capture condition, the stress due to moment at top fiber is:

$$f_{\text{top}} = \frac{M \times y_{\text{top}}}{I}$$

### 4.3.2 Illustrative Example

The cantilever beam shown in Figure 4.3-3 is loaded at its tip and prestressed with a sloping tendon as indicated. To simplify the problem, selfweight, creep, shrinkage, aging of concrete and relaxation in prestressing are all suppressed. No stress loss in post-tensioning is included. The objective is to demonstrate the computation and interpretation of moments and stresses at pre-. and post-capture cases.

Consider section a-a, 45-in. from the support. The section is at the J, node of element, 3, (Figure 4.3-3(d)). The actions and stresses for this section at pre-. and post-capture stages will be reviewed next. The input data for this example is also appended at the end of this review. Units are all in lb-in.

The tendon makes an angle, $\theta = 30.964^\circ$, with the centroidal axis.

(i) External actions at section a-a:

$$M = -30,000 \times 15 = -450,000$$
$$N = -40,000$$
$$V = 30,000$$

Components of the prestressing force (P) at section a-a:

$$P = 50,000 \text{ lb.}$$
$$P_x = 50,000(\cos 30.964) = 42,874 \text{ lb.}$$
$$P_y = 50,000(\sin 30.964) = 25,725 \text{ lb.}$$
(ii) Pre-capture internal actions at section a-a:

\[ e = 9 \]
\[ P = 50,000 \]
\[ P_x = 50,000 \cos \theta = 42,874 \]
\[ P_y = 50,000 \sin \theta = 25,725 \]
\[ M_c = M - P_x \cdot e \\ = -450,000 - 42,874 \cdot 9 = -835,866 \]  
(ADAPT-GEN output, data block 107.1 gives -835,870, OK)
\[ V_c = V - P_y \\ = 30,000 - 25,725 = 4,275 \]  
(ADAPT-GEN output, data block 107.1 gives 4275.2, OK)
\[ N_c = N - P_x \\ = -40,000 - 42,874 = -82,874 \]  
(ADAPT-GEN output, data block 107.1 gives 82,875, OK)

Section modulus, \( S = 10 \cdot 40^2 / 6 = 2666.7 \)

Area = 10 \cdot 40 = 400

Tension stress in concrete \( = \frac{M_c}{S} - \frac{N_c}{A} \)
\[ = \frac{835,866}{2666.7} - \frac{82,874}{400} \]
\[ = 106.26 \]  
(ADAPT-GEN output, data block 108 gives 106.27, OK)

(iii) Post-capture internal actions at section a-a:

\[ M = -450,000 \]  
(ADAPT-GEN output, data block 107.1 gives -450,000)
\[ N = -40,000 \]  
(ADAPT-GEN output, data block 107.1 gives -40,000)
\[ V = 30,000 \]  
(ADAPT-GEN output, data block 107.1 gives 30,000)

Tension stress \( = \frac{450,000}{2,666.7} - \frac{40,000}{400} = 68.75 \)  
(ADAPT-GEN output, data block 108 gives 68.75)

Note that for the post-capture condition, the stresses in concrete do not include pre-stressing.
POST TENSIONED CANTILEVER BEAM

FIGURE 4.3-3
(iv) Input File

;=====================================================================
; ADAPT-BRIDGE-INCREMENTAL   ABI   SOFTWARE MANUAL EXAMPLES
;=====================================================================
; Name of this file: GEN-EX01.INP
; Units are in lb-in

START
TITLE N=1
  CANTILEVER BEAM WITH PRESTRESSED TENDON

CONCRETE PARAMETERS N=1
  1 M=ACI a=0 b=1 ;no aging

MESH INPUT
  NODES N=5
    1 X=0 Y=0.0 ! 5 X=60 Y=0.0 G=1,5,1

CONCRETE PROPERTIES N=1
  1 Fpc=4000 Cr=0.0 Sh=0.0 W=0.0 ;no creep and shrinkage

SECTION PROPERTIES N=1
  1 D=40 B=10

ELEMENTS N=4
  FRAME N=4
    1,1,2 C=1 X=1 Day=1 G=1,4,1,1,1

PRESTRESSING STEEL N=1
  1 Ep=2.87E7 Meu=0.0 K=0.0 Fpu=270000 ;no friction

TENDON GEOMETRY N=1
  1 Spans=1 M=1 Area=0.306
    1 N=5
      LIST=1,2,3,4,5
      1 r=0 s=18
      2 r=15 s=9
      3 r=30 s=0
      4 r=45 s=-9
      5 r=60 s=-18

MESH COMPLETE

CHANGE STRUCTURE
  BUILD N=1,4,1
  RESTRAINTS
    1 R=1,1,1

  STRESS N=1 Force=0.50000

CHANGE COMPLETE
4.4 HYPERSTATIC ACTIONS: SECONDARY ACTIONS

The hyperstatic (secondary) actions are moments, shears, and axial loading, caused by the restraint of the supports to free deformation of the structure under prestressing load. At post-capture condition, the hyperstatic actions (secondary) are computed by the software. Hyperstatic actions are calculated incrementally accounting for load and stress history of the structure. At each increment of time or loading, the associated increment of hyperstatic actions are given by:

\[ M_{hp} = M_p - P \cdot e \]
\[ N_{hp} = N - P \]
\[ V_{hp} = V - V_p \]

where,

- \( M_{hp} \) = Hyperstatic (secondary) moment
- \( M_p \) = Moment due prestressing forces
- \( P \) = Combined force of prestressing tendons in a member
- \( e \) = Combined eccentricity of prestressing tendons
- \( N_{hp} \) = Hyperstatic axial loading
- \( N \) = Axial force in a member due to application of the prestressing forces on the structure
- \( V_{hp} \) = Hyperstatic shear
- \( V \) = Shear, including contribution of tendons, in a section caused by the action of prestressing forces on the structure
- \( V_p \) = Combined component of prestressing force in plane of section
4.5 ENVELOPES AND COMBINATIONS

The load combinations are linear addition of solutions obtained from loading components, each multiplied by a coefficient called for in the load combination. The envelopes give the maxima of the actions and displacements at each location.
5.1 GENERAL

The output of ADAPT-GEN is identical to ADAPT-ABI basic, using the same data block numbering and organization, except as detailed in this chapter.

5.2 CONSTRUCTION PHASE (PRE-CAPTURE)

The only addition to pre-construction phase is the definition of structure- if the option is used. The structure defined is printed out in data block 6, as shown in the following, extracted from example GEN-EX62.

6. STRUCTURAL DEFINITION AND INPUT DATA
=======================================
6.1 LEVELS OF THE STRUCTURE
-----------------------------
LEVEL = LEV1
Span = 1
   NODES 44 45 46 47 48 49 50
   ELEMENTS 41 42 43 44 45 46
Span = 2
   NODES 51 52 53 54 55 56 57
   ELEMENTS 49 50 51 52 53 54
Span = 3
   NODES 58 59 60 61 62 63 64
   ELEMENTS 57 58 59 60 61 62
Span = 4
   NODES 65 66 67
   ELEMENTS 65 66

LEVEL = LEV2
Span = 1
   NODES 68 69 70 71 72 73 74
   ELEMENTS 68 69 70 71 72 73
Span = 2
   NODES 75 76 77 78 79 80 81
   ELEMENTS 76 77 78 79 80 81

6.1 COLUMN GRID LINES
---------------------
GRID = AA
Column = 1
   NODES 1 2 3 4 5
   ELEMENTS 4 5 6 7
Column = 2
   NODES 7 8 9 10 11
   ELEMENTS 10 11 12 13

GRID = BB
Column = 1
   NODES 14 15 16 17 18
   ELEMENTS 15 16 17 18
Column = 2
   NODES 20 21 22 23 24
   ELEMENTS 21 22 23 24
Column = 3
   NODES 26 27 28
   ELEMENTS 27 28

GRID = CC
Column = 1
   NODES 30 31 32 33 34
   ELEMENTS 30 31 32 33
5.3 REGULAR LOADING CASES

A regular loading case is one which does not include skipping of loads, combinations, envelopes, nor does it include prestressing. The output for a regular loading case is the same as ADAPT-ABI, with the exception that no prestressing is output.

5.4 PATTERNED (SKIPPED) LOADING CASES; ENVELOPES

The output for skipped load cases and envelopes use the same format. The format is differentiated from the regular output printout, in that, for the skipped and enveloped cases the maxima and minima of the actions are each listed together with the associated values of other actions or displacements. For example, the maximum moment at a section is printed with its associated shear and axial loading. Likewise, the maximum shear at the same location is printed with the moment and axial loading which corresponds with that shear.

Examples of the printout are given next:

```plaintext
5.4 PATTERNED (SKIPPED) LOADING CASES; ENVELOPES

Examples of the printout are given next:

--- NON-TIME-DEPENDENT SOLUTIONS : ENVELOPE LIVE ---

### 104 LOADING

#### 104.1 EXTERNALLY APPLIED LOADING

<table>
<thead>
<tr>
<th>NODE</th>
<th>X-FORC</th>
<th>Y-FORC</th>
<th>Z-MOMENT</th>
<th>X-DISP</th>
<th>Y-DISP</th>
<th>Z-ROTN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0000E+00</td>
<td>-1.2500E+02</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
</tr>
<tr>
<td>2</td>
<td>0.0000E+00</td>
<td>-2.2500E+02</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
</tr>
<tr>
<td>3</td>
<td>0.0000E+00</td>
<td>-1.0000E+02</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
</tr>
<tr>
<td>6</td>
<td>0.0000E+00</td>
<td>-1.0000E+02</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
</tr>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>-1.0000E+02</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
</tr>
</tbody>
</table>

#### 104.2 ELEMENT TEMPERATURES

<table>
<thead>
<tr>
<th>FRAME</th>
<th>TOP FIBER</th>
<th>BOTTOM FIBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
</tr>
</tbody>
</table>

--- DISPLACEMENTS AT THE NODES ---

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>LEV1</th>
<th>SPAN</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>NODE</td>
<td>U-max</td>
<td>V-max</td>
<td>ROT-max</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>---------</td>
</tr>
<tr>
<td>1</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>-6.4838E-08</td>
</tr>
<tr>
<td>2</td>
<td>-1.2451E-11</td>
<td>-6.0423E-07</td>
<td>-5.1594E-08</td>
</tr>
</tbody>
</table>
## Chapter 5

### ADAPT Output

#### Level Lev1  Span 2

<table>
<thead>
<tr>
<th>Node</th>
<th>U-max</th>
<th>V-max</th>
<th>ROT-max</th>
<th>U-min</th>
<th>V-min</th>
<th>ROT-min</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-1.2451E-11</td>
<td>-6.0423E-07</td>
<td>-5.1594E-08</td>
<td>-2.3346E-11</td>
<td>-1.5071E-06</td>
<td>-1.3441E-07</td>
</tr>
<tr>
<td>3</td>
<td>-7.8160E-11</td>
<td>-9.8029E-07</td>
<td>-2.2870E-08</td>
<td>-1.6759E-10</td>
<td>-2.5620E-06</td>
<td>-7.2075E-08</td>
</tr>
</tbody>
</table>

### 106.1 - Reactions at Fixed Nodes; Maxima and Minima Values

<table>
<thead>
<tr>
<th>Node</th>
<th>X-Force</th>
<th>Y-Force</th>
<th>Z-Moment</th>
<th>R-Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.7903E-02</td>
<td>-6.2499E+02</td>
<td>0.0000E+00</td>
<td>6.2499E+02</td>
</tr>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>-2.5416E+02</td>
<td>0.0000E+00</td>
<td>2.5416E+02</td>
</tr>
</tbody>
</table>

### 106.2 - Reactions at Fixed Nodes; Maxima and Minima Values

<table>
<thead>
<tr>
<th>Node</th>
<th>X-Force</th>
<th>Y-Force</th>
<th>Z-Moment</th>
<th>R-Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.7903E-02</td>
<td>-6.2499E+02</td>
<td>0.0000E+00</td>
<td>6.2499E+02</td>
</tr>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>-5.0832E+02</td>
<td>0.0000E+00</td>
<td>5.0832E+02</td>
</tr>
</tbody>
</table>

### 106.3 - Reactions at Fixed Nodes; Maxima and Minima Values

<table>
<thead>
<tr>
<th>Node</th>
<th>X-Force</th>
<th>Y-Force</th>
<th>Z-Moment</th>
<th>R-Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-9.6975E-03</td>
<td>-3.9583E+02</td>
<td>0.0000E+00</td>
<td>3.9583E+02</td>
</tr>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>-2.5416E+02</td>
<td>0.0000E+00</td>
<td>2.5416E+02</td>
</tr>
</tbody>
</table>

### 106.4 - Reactions at Fixed Nodes; Maxima and Minima Values

<table>
<thead>
<tr>
<th>Node</th>
<th>X-Force</th>
<th>Y-Force</th>
<th>Z-Moment</th>
<th>R-Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.7903E-02</td>
<td>-6.2499E+02</td>
<td>0.0000E+00</td>
<td>6.2499E+02</td>
</tr>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>-5.0832E+02</td>
<td>0.0000E+00</td>
<td>5.0832E+02</td>
</tr>
</tbody>
</table>

### Level Lev1  Span 1

#### 107.1m; Moments: Maxima and Minima Values

<table>
<thead>
<tr>
<th>No</th>
<th>Moment-max Shear Axial</th>
<th>Moment-min Shear Axial</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I</td>
<td>1.1829E+11 4.9999E+02 -1.7903E-02</td>
<td>3.9160E-12 2.7083E+02 -9.6975E-03</td>
</tr>
<tr>
<td>1 J</td>
<td>4.9999E+03 4.9999E+02 -1.7903E-02</td>
<td>2.6666E+03 2.6666E+02 -9.5483E-03</td>
</tr>
</tbody>
</table>

#### 107.1s; Shears: Maxima and Minima Values

<table>
<thead>
<tr>
<th>No</th>
<th>Shear-max Axial</th>
<th>Shear-min Axial</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I</td>
<td>1.1829E-11 2.6666E+02 -9.5483E-03</td>
<td>1.1829E-11 2.6666E+02 -9.5483E-03</td>
</tr>
<tr>
<td>1 J</td>
<td>2.6666E+03 2.6666E+02 -9.5483E-03</td>
<td>2.6666E+03 2.6666E+02 -9.5483E-03</td>
</tr>
</tbody>
</table>

#### 107.1a; Axial Loading: Maxima and Minima Values

<table>
<thead>
<tr>
<th>No</th>
<th>Moment Shear Axial-max</th>
<th>Moment Shear Axial-min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I</td>
<td>1.1319E-11 2.6666E+02</td>
<td>1.1829E-11 2.6666E+02</td>
</tr>
<tr>
<td>1 J</td>
<td>2.6666E+03 2.6666E+02</td>
<td>2.6666E+03 2.6666E+02</td>
</tr>
</tbody>
</table>

### 108 - Extreme Fiber Stresses in Concrete

<table>
<thead>
<tr>
<th>Element</th>
<th>Top-max</th>
<th>Top-min</th>
<th>Bot-max</th>
<th>Bot-min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I</td>
<td>-4.7742E-06 -8.9516E-06</td>
<td>-4.7742E-06 -8.9516E-06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 J</td>
<td>-2.0000E-01 -3.7500E-01</td>
<td>3.7499E-01 1.9999E-01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.5 PRESTRESSING

The output for prestressing lists both the actions and displacements due to prestressing, as well as the hyperstatic actions precipitated by prestressing forces. Examples of the associated data blocks are given in the following.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>SPAN</th>
<th>NODE</th>
<th>U</th>
<th>V</th>
<th>ROT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEV1</td>
<td>1</td>
<td>1</td>
<td>0.0000E+00</td>
<td>0.0000E+00</td>
<td>2.7310E-06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>-7.6142E-06</td>
<td>2.6549E-05</td>
<td>2.5026E-06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>SPAN</th>
<th>NODE</th>
<th>U</th>
<th>V</th>
<th>ROT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEV1</td>
<td>2</td>
<td>2</td>
<td>-7.6142E-06</td>
<td>2.6549E-05</td>
<td>2.5026E-06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>-1.6025E-05</td>
<td>4.8263E-05</td>
<td>1.7614E-06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NODE</th>
<th>X-FORCE</th>
<th>Y-FORCE</th>
<th>Z-MOMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.2129E+00</td>
<td>-9.7029E-01</td>
<td>0.0000E+00</td>
</tr>
<tr>
<td>7</td>
<td>0.0000E+00</td>
<td>-1.7169E+00</td>
<td>0.0000E+00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>SPAN</th>
<th>ELEMENT</th>
<th>BENDING (END I)</th>
<th>BENDING (END J)</th>
<th>SHEAR</th>
<th>AXIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEV1</td>
<td>1</td>
<td>1</td>
<td>-9.5497E-12</td>
<td>-4.6712E+04</td>
<td>-4.6712E+03</td>
<td>-5.8389E+03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>I-TOP</th>
<th>I-BOT</th>
<th>J-TOP</th>
<th>J-BOT</th>
<th>AXIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-2.9195E+00</td>
<td>-2.9195E+00</td>
<td>5.8389E-01</td>
<td>-6.4228E+00</td>
<td>-2.9195E+00</td>
</tr>
<tr>
<td>2</td>
<td>-5.1600E+04</td>
<td>-9.9975E+04</td>
<td>-4.8375E+03</td>
<td>-6.4500E+03</td>
<td></td>
</tr>
</tbody>
</table>
5.6 COMBINATIONS

A loading combination can result in two possible types of printout.

(i) If the components of the combination are all regular loading cases (without skipping), the combination output will also have the format of a regular printout as described in the preceding.

(ii) When one of the components of the load combination is an envelope, the printout format of the combination will also be an envelope.
6.1 GENERAL

ADAPT-GEN is capable of treating frames in building, bridges and special structures. These can be pre-stressed or non-prestressed concrete; of composite construction; incrementally constructed, or be a complete construction. They can have time-dependent, or time-free response. In this chapter, three examples are selected to illustrate some of the capabilities of ADAPT-Gen. Example 1, is a simple post-tensioned frame, viewed as if constructed in one stage. Example 1 is a frame common to parking structures with split level. It is constructed in stages.

The focus of the examples is the features particular to ADAPT-GEN, such as handling of the frames as structures, load combinations and envelopes. In particular, in example 1 an attempt is made to illustrate all alternatives of load specification included in ADAPT-GEN. As a result, some of the loading conditions selected for the example may appear unrealistic, from a practical point of view.

6.2 EXAMPLE 1: EXTRACTION OF TIME-DEPENDENT EFFECTS

6.2.1 Description

From the total integrated solution obtained by ADAPT-ABI, the program ADAPT-GEN has the capability to separate the solution to its components due to “applied loading”, “prestressing,” and “long-term effects” of creep and shrinkage. The objective of this example is to illustrate the extraction of the actions and displacements due to creep and shrinkage.

The structure considered is a two span beam shown in Figure 6.2.1-1. The beam consists of two single span girders which are installed next to one another over the central support and made continuous through a cast-in-place splice. Loading is limited to self weight. Creep and shrinkage over time will result in a change in the distribution of actions in the structure.

The distribution of moment due to selfweight after 7300 days is shown in Figure 6.2.1-2. The moment due to selfweight at the time the girders were made continuous was as shown in Figure 6.2.1-4. The moments generated due to the creep and shrinkage of the girders are shown in Figure 6.2.1-5. Note that the moment due to creep and shrinkage are comparable in magnitude to those due to selfweight. In this example due to roller end supports shrinkage does not cause moments. Hence Figure 6.2.1-5 reflects the effects of creep only.

Figure 6.2.1-3 shows the combination of moments due to selfweight and long-term effects obtained from the last stage of ADAPT-ABI and shown in Figure 6.2.1-2.
(a) INSTALLATION OF PRECAST GIRDER

(b) CLOSURE OF SPLICE

TWO SPAN SPliced GIRDER CONSTRUCTION

FIGURE 6.2.1-1
FIGURE 6.2.1-2

Maximum Moment = 1.08E+08
Minimum Moment = -1.50E+08

Distribution of moment along the length of the continuous girders after 20 years

Solution from ABI-Gen for the combined effects of selfweight, creep and shrinkage

FIGURE 6.2.1-3
FIGURE 6.2.1-4

Moment due to self-weight of the girders

FIGURE 6.2.1-5

Moment due to the long-term effects of creep and shrinkage over 20 years
6.2.2 Input Data

This example illustrates the modeling of precast girders spliced for continuity. It is also used to illustrate the extraction of effects of creep and shrinkage from the integrated solution.

START

UNITS U=SI

ACTIVATE EXTRACT

CONCRETE PARAMETERS ! 1 M=ACI

MESH INPUT

NODES N=19
  1 X=0.0 Y=0.0 ; Left span, left support
  5 X=8.28*1000 Y=0.0 G=1,5,1 ; Left support to pt vertex
  9 X=20.0-0.15*1000 Y=0.0 G=5,9,1 ; Pt vertex to right support
  10 X=20.0*1000 Y=0.0 ; Mid support
  11 X=20.0+0.15*1000 Y=0.0 ; Right span, left support
  15 X=40.0-8.28*1000 Y=0.0 G=11,15,1 ; Left support to pt vertex
  19 X=40.0*1000 Y=0.0 G=15,19,1 ; Pt vertex to right support

SECTION PROPERTIES N=1
  1 B=250.0 D=600.0 ; Rectangular

CONCRETE PROPERTIES N=2
  1 FPC=45.00 CR=2.5 SH=0.0004 W=0.0000024 Ac=0.0 ; Precast
  2 FPC=35.00 CR=2.5 SH=0.0004 W=0.0000024 Ac=0.0 ; Splice

MILD STEEL PROPERTIES N=1
  1 Es=200000 P=0.0 ; no passive steel

ELEMENTS N=18

FRAME N=18
  1, 1, 2 C=1 X=1 Day=0 ST=1 G= 1, 8,1,1,1,0,0,0,0,0,0 ; Left girder
  9, 9,10 C=2 X=1 Day=0 ST=1 G= 9,10,1,1,1,0,0,0,0,0,0 ; Splice
  11,11,12 C=1 X=1 Day=0 ST=1 G=11,18,1,1,1,0,0,0,0,0,0 ; Right girder
MESH COMPLETE

; Construction phase

SET Day=0  G=0,-1  ; Cast girders in bed

; cast concrete

CHANGE STRUCTURE
BUILD N=1,8  Day=0  ; Cast span 1 at day=0
BUILD N=11,18  Day=0  ; Cast span 2 at day=0

RESTRAINTS
   1 R=1,1,0  !  9 R=0,1,0
   11 R=1,1,0  ! 19 R=0,1,0

CHANGE COMPLETE
SOLVE Day=3  ! OUTPUT  ; Update stress status

SOLVE Day=14  ! OUTPUT

SOLVE Day=32  ; update stresses to Day 32
CHANGE STRUCTURE
BUILD N=9,10  ; build splice segment

RESTRAINTS
   9 R=0,0,0  !  11 R=0,0,0  ! 10 R=0,1,0

CHANGE COMPLETE
SOLVE ! OUTPUT

SOLVE Day=50  ! OUTPUT
SOLVE Day=100  ! OUTPUT
SOLVE Day=200  ! OUTPUT
SOLVE Day=365  ! OUTPUT
SOLVE Day=365*10  ! OUTPUT
SOLVE Day=365*20  ! OUTPUT

; extract components of actions for load combination
; and service stress checks

CAPTURE STATUS

LOADING DL
DEAD LOAD  ; Dead load actions
SOLVE
OUTPUT

LOADING LT
LONG TERM
SOLVE
OUTPUT

COMBINATIONS
COMBINATION TOTAL  ; DL+LT  Service
   1*DL+1*LT

STOP
6.3 EXAMPLE 1: TWO-STORY POST-TENSIONED FRAME

6.3.1 Description

The elevation of the two-story plane frame is given in Figure 6.3-1. The support conditions are fixed (Grid A), one fixed hinge (Grid B); one on elastic springs (Grid D) (Figure 6.3.2(a)).

The cross sectional properties of the frame and the material used are given in the following tables. These are identified in Figure 6.3-2(b).

A. Cross-sectional properties:

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (in²)</th>
<th>Moment of Inertia (in⁴)</th>
<th>C_top</th>
<th>C_bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>400</td>
<td>14,000</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>X2</td>
<td>300</td>
<td>10,000</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>X3</td>
<td>600</td>
<td>50,000</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>X4</td>
<td>500</td>
<td>30,000</td>
<td>7</td>
<td>19</td>
</tr>
</tbody>
</table>

B. Material Properties:

Concrete:

<table>
<thead>
<tr>
<th>Designation</th>
<th>f’c (psi)</th>
<th>Creep coefficient</th>
<th>Shrinkage coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>6000</td>
<td>3.0</td>
<td>0.0004</td>
</tr>
<tr>
<td>C2</td>
<td>5000</td>
<td>2.5</td>
<td>0.0003</td>
</tr>
<tr>
<td>C3</td>
<td>4000</td>
<td>2.0</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Unit weight of concrete: \( W = \frac{155}{1728} \text{ lb/ft}^3 \)

Thermal expansion coefficient: \( A_c = 5.5E-06 \)
Steel:

Modulus Elasticity: \( E_s = 29,000 \text{ ksi} \)
Thermal expansion coefficient: \( A_s = 0.00006 \)

Springs:

Horizontal spring: \( K = 100,000 \text{ lb/in} \)
Vertical spring: \( K = 100,000 \text{ lb/in} \)

C. Prestressing:

The beams are prestressed each with a continuous profiled tendon. In addition the column at line C is prestressed with a single tendon located at centroid of the column. An overview of the tendon layout is given in Figure 6.3-3. The tendons are identified as tendons T1 though T3. The parameters defining the geometry of each tendon are also entered in the diagram. For additional details on the geometry parameters, R, and, S, refer to ADAPT-ABI program manual.
PT Angular friction coefficient = 0.2
PT Wobble friction coefficient = 0.0002
PT Ultimate stress = 270,000 lb/in

FIGURE 6.3-2
Tendon type | Area (in²)
---|---
T1 | 2.659
T2 | 1.839
T3 | 1.169

D. Loading:

1 - Dead loading

<table>
<thead>
<tr>
<th>Designation</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1, Span 1</td>
<td>2.00 kips/ft</td>
</tr>
<tr>
<td>Level 1, Span 2</td>
<td>0.75 kips/ft</td>
</tr>
<tr>
<td>Level 1, Span 3</td>
<td>0.75 kips/ft</td>
</tr>
<tr>
<td>Level 1, Span 4</td>
<td>0.70 kips/ft</td>
</tr>
<tr>
<td>Level 2, Span 1</td>
<td>0.90 kips/ft</td>
</tr>
<tr>
<td>Level 2, Span 2</td>
<td>0.80 kips/ft</td>
</tr>
</tbody>
</table>

2 - Prestressing

<table>
<thead>
<tr>
<th>Tendon type</th>
<th>Jacking stress ratio</th>
<th>Anchorage Slip</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.85</td>
<td>0.25</td>
</tr>
<tr>
<td>T2</td>
<td>0.85</td>
<td>0.25</td>
</tr>
<tr>
<td>T3</td>
<td>0.85</td>
<td>0.25</td>
</tr>
</tbody>
</table>

3 - Live loading

Uniform live load (LIVE1)

<table>
<thead>
<tr>
<th>Designation</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1, Span 1</td>
<td>1.00 kips/ft</td>
</tr>
<tr>
<td>Level 1, Span 2</td>
<td>0.85 kips/ft</td>
</tr>
<tr>
<td>Level 1, Span 3</td>
<td>0.85 kips/ft</td>
</tr>
<tr>
<td>Level 1, Span 4</td>
<td>0.85 kips/ft</td>
</tr>
<tr>
<td>Level 2, Span 1</td>
<td>1.20 kips/ft</td>
</tr>
<tr>
<td>Level 2, Span 2</td>
<td>1.30 kips/ft</td>
</tr>
</tbody>
</table>

Alternative live loading (LIVE2)

<table>
<thead>
<tr>
<th>Designation</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1, at Node 46</td>
<td>8.00 kips</td>
</tr>
<tr>
<td>Level 1, at Node 48</td>
<td>4.00 kips</td>
</tr>
<tr>
<td>Level 1, Span 2 at XB=6' XE=12'</td>
<td>0.30 kips/ft</td>
</tr>
<tr>
<td>Level 1 at Node 61</td>
<td>4.00 kips</td>
</tr>
<tr>
<td>Level 2, at Node 71</td>
<td>1.20 kips/ft</td>
</tr>
<tr>
<td>Level 2, at Node 78</td>
<td>1.30 kips/ft</td>
</tr>
</tbody>
</table>
Live loading is skipped to maximize values. A number of envelope and combination loading cases are selected, as shown in the input data, to illustrate the load specification.

4 - Lateral loading:

Earthquake load

<table>
<thead>
<tr>
<th>Designation</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Node 6</td>
<td>6 kips</td>
</tr>
<tr>
<td>At Node 12</td>
<td>12 kips</td>
</tr>
<tr>
<td>At Node 28</td>
<td>1 kips</td>
</tr>
</tbody>
</table>

Wind load

<table>
<thead>
<tr>
<th>Designation</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid AA, Column 1 &amp; 2</td>
<td>0.30 kips/ft</td>
</tr>
<tr>
<td>Grid CC, Column 1</td>
<td>0.20 kips/ft</td>
</tr>
<tr>
<td>Grid BB, at Node 28</td>
<td>1.00 kips</td>
</tr>
</tbody>
</table>

A summary of frame loading described above is shown in Figure 6.3-4. A finite element discretization of the frame is modeled as the one shown in Figure 6.3-5.
(a) SUPER IMPOSED DEAD LOAD IN ADDITION TO SELF WEIGHT

(b) UNIFORM LIVE LOAD ON SPANS (LL1)

(c) ALTERNATIVE LIVE LOADING (LL2)

FRAME LOADING CONT...

FIGURE 6.3-4
(d) WIND LOADING (WIND)

(e) EARTHQUAKE LOADING

FRAME LOADING

FIGURE 6.3-4
FIGURE 6.3-5
6.3.2 Input Data

;======================================================================
; ADAPT-BRIDGE-INCREMENTAL ABI SOFTWARE MANUAL EXAMPLES
;======================================================================
; name of this file: GEN-ex62.INP

START
TITLE N=1
   TWO-STORY POST-TENSIONED FRAME

UNITS U=USA

CONCRETE PARAMETERS N=1
   1 M=ACI a=0 b=1 W=155/1728 ; suppress concrete aging

MESH INPUT
NODES N=81
   1 X=0 Y=0
   5 X=0 Y=151 G=1,5,1
   6 X=0 Y=180
   7 X=0 Y=191
   11 X=0 Y=305 G=7,11,1
   12 X=0 Y=324
   13 X=384 Y=-36.18
   14 X=384 Y=-36
   18 X=384 Y=151 G=14,18,1
   19 X=384 Y=180
   20 X=384 Y=191
   24 X=384 Y=305 G=20,24,1
   25 X=384 Y=324
   26 X=384 Y=331
   28 X=384 Y=384 G=26,28,1
   29 X=600 Y=180
   30 X=600 Y=191
   34 X=600 Y=305 G=30,34,1
   35 X=600 Y=324
   36 X=840 Y=-72
   37 X=900 Y=-12
   38 X=840 Y=-12
   42 X=840 Y=151 G=38,42,1
   43 X=840 Y=180
   44 X=11 Y=180
   50 X=375 Y=180 G=44,50,1
   51 X=395 Y=180
   57 X=593 Y=180 G=51,57,1
   58 X=613 Y=180
   64 X=831 Y=180 G=58,64,1
   65 X=851 Y=180
   67 X=900 Y=180 G=65,67,1
   68 X=13 Y=324
   74 X=377 Y=324 G=68,74,1
   75 X=397 Y=324
   81 X=593 Y=324 G=75,81,1
ADAPT EXAMPLES Chapter 6

CONCRETE PROPERTIES N=3
1 Fpc=6000 Cr=3.0 Sh=0.0004 W=155/1728 Ac=0.0000055
2 Fpc=5000 Cr=2.5 Sh=0.0003 W=155/1728 Ac=0.0000055
3 Fpc=4000 Cr=2.0 Sh=0.006 W=155/1728 Ac=0.0000055

MILD STEEL PROPERTIES N=1
1 Es=29000000 P=.02 As=0.00006

SECTION PROPERTIES N=4
1 Area=400 I=14000 C=9,11 ;level 1 column property
2 Area=300 I=10000 C=7,13 ;level 2 column property
3 Area=600 I=50000 C=11,29 ;level 1 span property
4 Area=500 I=30000 C=7,19 ;level 2 span property

ELEMENTS N=82
FRAME N=80
3,13,14 C=1 X=1 St=1 Day=1
4, 1 ,2 C=1 X=1 St=1 Day=1 G=4,8,1,1,1
9, 6, 7 C=2 X=2 St=1 Day=1 G=9,14,1,1,1
15,14,15 C=1 X=1 St=1 Day=1 G=15,19,1,1,1
20,19,20 C=2 X=2 St=1 Day=1 G=20,28,1,1,1
29,29,30 C=2 X=2 St=1 Day=1 G=29,34,1,1,1
35,38,39 C=1 X=1 St=1 Day=1 G=35,39,1,1,1
40,6,44 C=3 X=3 St=1 Day=1
41,44,45 C=3 X=3 St=1 Day=1 G=41,46,1,1,1
47,50,19 C=3 X=3 St=1 Day=1
48,19,51 C=3 X=3 St=1 Day=1
49,51,52 C=3 X=3 St=1 Day=1 G=49,54,1,1,1
55,57,29 C=3 X=3 St=1 Day=1
56,29,58 C=3 X=3 St=1 Day=1
57,58,59 C=3 X=3 St=1 Day=1 G=57,62,1,1,1
63,64,43 C=3 X=3 St=1 Day=1
64,43,65 C=3 X=3 St=1 Day=1
65,65,66 C=3 X=3 St=1 Day=1 G=65,66,1,1,1
67,12,68 C=3 X=4 St=1 Day=1
68,68,69 C=3 X=4 St=1 Day=1 G=68,73,1,1,1
74,74,25 C=3 X=4 St=1 Day=1
75,25,75 C=3 X=4 St=1 Day=1
76,75,76 C=3 X=4 St=1 Day=1 G=76,81,1,1,1
82,81,35 C=3 X=4 St=1 Day=1

SPRINGS N=2
1,36,38 K=100000
2,37,38 K=100000

PRESTRESSING STEEL N=1
1 Ep=2.8E7 Meu=0.2 K=0.0002 Fpu=270000 Fpy=256000 \ R=45 Ap=0.0

TENDON GEOMETRY N=3
1 Spans=3 M=1 Area=2.659
1 N=9 B=0,180 E=384,180
   List=6,44,45,46,47,48,49,50,19
   R=0.0, 0.4, 0.1 S=0.0, -25,8
2 N=17 B=384,180 E=840,180
   List=19,51,52,53,54,55,56,57,58,59,60,61,\ 62,63,64,43
   R=0.1, 0.5, 0.1 S=8,-25,2
3 N=4 B=840,180 E=900,180
   List=43,65,66,67
R=0.0,1.0,0.0 S=2,0.0,0.0
2 Spans=2 M=1 Area=1.839
1 N=9 B=0,324 E=384,324
List=12,68,69,70,71,74,75
R=0.0,0.4,0.1 S=0.0,-15,4
2 N=9 B=384,324 E=600,324
List=25,75,76,77,79,80,81,35
R=0.1,0.6,0.0 S=4,-15,0.0
3 Spans=1 M=1 Area=1.169
1 N=7 G=29,35,1 B=600,180 E=600,324
R=0.0,0.0,0.0 S=0.0,0.0,0.0

MESH COMPLETE

STRUCTURE DEFINITION
GRIDS 4 LEVELS 2
GRID AA
COLUMN 1 E=4,7,1
COLUMN 2 E=10,13,1
GRID BB
COLUMN 1 E=15,18,1
COLUMN 2 E=21,24,1
COLUMN 3 E=27,28,1
GRID CC
COLUMN 1 LIST=30,31,32,33
GRID DD
COLUMN 1 E=35,38,1
LEVEL LEV1
SPAN 1 E=41,46,1
SPAN 2 E=49,54,1
SPAN 3 E=57,62,1
SPAN 4 LIST=65,66
LEVEL LEV2
SPAN 1 E=68,73,1
SPAN 2 E=76,81,1
STRUCTURE COMPLETE

CHANGE STRUCTURE
BUILD N=4,8,1 Day=7
BUILD N=3 Day=7
BUILD N=15,19,1 Day=7
BUILD N=1,2,1 Day=7
BUILD N=35,39,1 Day=7
RESTRAINTS
1 R=1,1,1
13 R=1,1,0
14 R=1,1,0
36 R=1,1,0
37 R=1,1,0

CHANGE COMPLETE

SOLVE Day=7
OUTPUT
CHANGE STRUCTURE
  BUILD N=40,47,1 Day=14
  BUILD N=48,55,1 Day=14
  BUILD N=56,63,1 Day=14
  BUILD N=66,64,-1 Day=14
  STRESS N=1 Ratio=0.85 Anchor=0.25,0.25

CHANGE COMPLETE
SOLVE Day=14 Steps=8
OUTPUT

CHANGE STRUCTURE
  BUILD N=10,14,1 Day=18
  BUILD N=21,28,1 Day=18
  BUILD N=30,34,1 Day=18
  BUILD N=67,74,1 Day=25
  BUILD N=75,82,1 Day=25
  BUILD N=9 Day=18
  BUILD N=20 Day=18
  BUILD N=29 Day=18
  STRESS N=2 Ratio=0.85 Anchor=0.25,0.25
  STRESS N=3 Ratio=0.85 Anchor=0.25,0.25

CHANGE COMPLETE
SOLVE Day=18
OUTPUT

SOLVE Day=45
OUTPUT

SOLVE Day=180 Steps=2
OUTPUT

SOLVE Day=365 Steps=2
OUTPUT

SOLVE Day=730 Steps=5
OUTPUT

CAPTURE STATUS
LOADING DL ; Superimposed Dead load

STRUCTURE
  LEVEL LEV1
  SPAN 1
    UNIFORM F=0,-2000/12
  SPAN 2
    UNIFORM F=0,-750/12
  SPAN 3
    UNIFORM F=0,-750/12
  SPAN 4
    UNIFORM F=0,-700/12
  LEVEL LEV2
  SPAN 1
UNIFORM  F=0,-900/12  
SPAN 2  
UNIFORM  F=0,-800/12  
SOLVE  
OUTPUT  
LOADING LIVE1  
; Liveload 1  
PATTERN  
LEVEL LEV1  
SPAN 1  
UNIFORM  F=0,-1000/12  
SPAN 2  
UNIFORM  F=0,-850/12  
SPAN 3  
UNIFORM  F=0,-850/12  
SPAN 4  
UNIFORM  F=0,-850/12  
LEVEL LEV2  
SPAN 1  
UNIFORM  F=0,-1200/12  
SPAN 2  
UNIFORM  F=0,-1300/12  
SKIP  
LEVEL LEV1 SPANS 1 0 1 0  
LEVEL LEV2 SPANS 0 1  
SKIP  
LEVEL LEV1 SPANS 0 1 0 1  
LEVEL LEV2 SPANS 1 0  
SKIP  
LEVEL LEV1 SPANS 1 1 1 1  
LEVEL LEV2 SPANS 1 1  
SKIP  
LEVEL LEV1 SPANS 1 1 0 1  
LEVEL LEV2 SPANS 1 1  
SOLVE  
OUTPUT  
LOADING LIVE2  
; Liveload 2  
STRUCTURE  
LEVEL LEV1  
SPAN 1  
CONCENTRATED  F=0,-8000,0  AT N=46  
CONCENTRATED  F=0,-4000,0  AT N=48  
SPAN 2  
UNIFORM  F=0,-300/12  XB=72 XE=144  
SPAN 3  
CONCENTRATED  F=0,-4000,0  AT N=61  
LEVEL LEV2  
SPAN 1  
CONCENTRATED  F=0,-10000,0  AT N=71  
SPAN 2  
CONCENTRATED  F=0,-12000,0  AT N=78  

6 - 20
SOLVE
OUTPUT

LOADING EQKE  ; Earthquake
   GENERIC
   N=6  F=8000,0,0
   N=12 F=12000,0,0
   N=28 F=1000,0,0

SOLVE
OUTPUT

LOADING WIND  ; Wind
   GENERIC
   N=28 F=2000,0,0
   STRUCTURE
      GRID AA
         COLUMN ALL
            UNIFORM F=300/12,0
      GRID CC
         COLUMN 1
            UNIFORM F=200/12,0

SOLVE
OUTPUT

LOADING PT  ; Prestressing load
   PRESTRESSING

SOLVE
OUTPUT

LOADING DEAD  ; Selfweight/Dead loading
   DEAD LOAD

SOLVE
OUTPUT

LOAD LT
   LONG TERM
   LOAD
SOLVE
OUTPUT

LOADING TEMP  ; Temperature loading
   STRUCTURE
      LEVEL LEV2
         SPAN 1
            TEMPERATURE L=68,73,1 T=110,85
         SPAN 2
            TEMPERATURE L=76,81,1 T=110,85

SOLVE
OUTPUT
6.4 EXAMPLE 3: THREE STORY PARKING STRUCTURE SPLIT FRAME

6.4.1 Description

The elevation of the three-story split frame, which is constructed in three stages, is given in Figure 6.4-1. The three supports of the frame are modeled as fixed.

The beams in each level are prestressed with a simple parabola tendon. Figure 6.4-2 shows the tendon arrangement of a typical level. The discretization and structural design models of the frame is shown in Figure 6.4-3.

```
COMBINATIONS
  COMBINATION ONE ; DL+LL1
      1.4*DEAD+1.4*PT+1.7*LIVE1
  OUTPUT

  COMBINATION TWO ; DL+LL1+WIND
      1.4*DEAD+1.4*PT+1.4*WIND+1.7*LIVE1
  COMBINATION THREE ; DL+LL2+WIND
      1.4*DEAD+1.4*PT+1.4*WIND+1.7*LIVE2
      ENVELOPE A
      ENVELOPE TWO,THREE
  OUTPUT

  COMBINATION FOUR ; EQKE+DL
      0.9*DEAD+0.9*PH+1.7*EQKE
      ENVELOPE B
      ENVELOPE ONE,THREE
  OUTPUT

  STOP
```
CONSTRUCTION STAGES OF AN OFFSET FRAME

FIGURE 6.4-1
Live loading is skipped to maximize values. A number of envelope and combination loading cases are selected, as indicated in the input data.

The structural model selected is shown in Figure 6.4-3. The specifics of the model are:

(i) The middle column at short intervals between the levels is modeled with essentially zero moment of inertia to simulate hinge supports at connection to the beams. This would necessitate either construction of a hinge detail at connection to the beam, or tightly placed ties in the column to increase confinement and accommodate the ensuing rotations.

(ii) The upper level exterior columns are modeled with an effective moment of inertia equal to one-quarter of the actual value. This would result in additional reinforcement in the beam span. Ties, tightly spaced at the top of the column should be provided to retain the integrity of the column while allowing joint rotation at this location.
(a) MODEL FOR FRAME DISCRETIZATION

(b) STRUCTURAL DEFINITION

STRUCTURAL MODEL

FIGURE 6.4-3
### 6.4.2 Input Data

The parking structure frame is three split levels. Each T-beam is a 17’ wide x 30 inches deep, with 5.5 thick flange, and a 16” wide beam stem. Live load is 50 psf.

```
START
TITLE N=1
THREE STORY PARKING STRUCTURE SPLIT FRAME

ACTIVATE EXTRACT
UNITS U=USA

CONCRETE PARAMETERS N=1
 1  M=ACI W=150/1728

MESH INPUT
NODES N=97
 1  X=0  Y=0     ! 3  X=0  Y=84  G=1,3
 4  X=0  Y=105.15
 5  X=0  Y=114   ! 7  X=0  Y=198 G=5,7
 8  X=0  Y=219.15
 9  X=0  Y=228   ! 11 X=0  Y=312 G=9,11
12  X=0  Y=333.15
13  X=756  Y=0     ! 15 X=756 Y=84  G=13,15
16  X=756  Y=105.15
17  X=756  Y=114
18  X=756  Y=132
19  X=756  Y=153.15
20  X=756  Y=162
21  X=756  Y=198
22  X=756  Y=219.15
23  X=756  Y=228
24  X=756  Y=246
25  X=756  Y=267.15
26  X=756  Y=276
27  X=756  Y=312
28  X=756  Y=333.15
29  X=756  Y=342
30  X=756  Y=360
31  X=756  Y=381.15
32  X=1512 Y=48    ! 34 X=1512 Y=132 G=32,34
35  X=1512 Y=153.15
36  X=1512 Y=162   ! 38 X=1512 Y=246 G=36,38
39  X=1512 Y=267.15
40  X=1512 Y=276   ! 42 X=1512 Y=360 G=40,42
43  X=1512 Y=381.15
44  X=-10   Y=105.15
```
45 \( X=10 \quad Y=105.15 \) ! 51 \( X=746 \quad Y=105.15 \) \( G=45,51 \)
52 \( X=766 \quad Y=105.15 \)
53 \( X=-10 \quad Y=219.15 \)
54 \( X=10 \quad Y=219.15 \) ! 60 \( X=746 \quad Y=219.15 \) \( G=54,60 \)
61 \( X=766 \quad Y=219.15 \)
62 \( X=-10 \quad Y=333.15 \)
63 \( X=10 \quad Y=333.15 \) ! 69 \( X=746 \quad Y=333.15 \) \( G=63,69 \)
70 \( X=766 \quad Y=333.15 \)
71 \( X=746 \quad Y=153.15 \)
72 \( X=766 \quad Y=153.15 \) ! 78 \( X=1502 \quad Y=153.15 \) \( G=72,78 \)
79 \( X=1522 \quad Y=153.15 \)
80 \( X=746 \quad Y=267.15 \)
81 \( X=766 \quad Y=267.15 \) ! 87 \( X=1502 \quad Y=267.15 \) \( G=81,87 \)
88 \( X=1522 \quad Y=267.15 \)
89 \( X=746 \quad Y=381.15 \)
90 \( X=766 \quad Y=381.15 \) ! 96 \( X=1502 \quad Y=381.15 \) \( G=90,96 \)
97 \( X=1522 \quad Y=381.15 \)

CONCRETE PROPERTIES \( N=1 \)
1 \( Fpc=4000 \quad Cr=2.5 \quad Sh=0.0005 \quad W=150/1728 \)

MILD STEEL PROPERTIES \( N=1 \)
1 \( Es=29000000 \quad P=0.05 \)

SECTION PROPERTIES \( N=4 \)
1 \( D=5.5,24.5 \quad B=104,16 \) ;SLAB PROPERTY
2 \( D=20 \quad B=20 \) ;COLUMN PROPERTY

OFFSET DATA \( N=3 \)
1 \( OI=0,0 \quad OJ=0,-21.15 \)
2 \( OI=0,8.85 \quad OJ=0,0 \)
3 \( OI=0,8.85 \quad OJ=0,-21.15 \)

ELEMENTS \( N=79 \)

FRAME \( N=79 \)
1,1,2 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \)
2,2,3 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
3,5,6 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=2 \)
4,6,7 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
5,9,10 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=2 \)
6,10,11 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
7,13,14 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \)
8,14,15 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
9,17,18 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=3 \)
10,20,21 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=3 \)
11,23,24 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=3 \)
12,26,27 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=3 \)
13,29,30 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=3 \)
14,32,33 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \)
15,33,34 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
16,36,37 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=2 \)
17,37,38 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
18,40,41 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=2 \)
19,41,42 \( C=1 \quad X=2 \quad St=1 \quad Day=1 \quad Off=1 \)
20,44,4 \( C=1 \quad X=1 \quad St=1 \quad Day=1 \)
21,4,45 \( C=1 \quad X=1 \quad St=1 \quad Day=1 \)
22,45,46 \( C=1 \quad X=1 \quad St=1 \quad Day=1 \quad G=22,27,1,1,1 \)
28,51,16 \( C=1 \quad X=1 \quad St=1 \quad Day=1 \)
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PRESTRESSING STEEL N=1

\[Ep=28000000 \quad Meu=0.07 \quad K=0.001/12 \quad Fpu=270000 \quad Fpy=255000 \quad R=45\]

TENDON GEOMETRY N=6

1 Spans=1 M=1 Area=1.377

1 N=9 B=0,105.15 E=756,105.15

LIST=4,45,46,47,48,49,50,51,16

R=0.05,0.5,0.05 S=0,-18.15,0

2 Spans=1 M=1 Area=1.377

1 N=9 B=0,219.15 E=756,219.15

LIST=8,54,55,56,57,58,59,60,22

R=0.05,0.5,0.05 S=0,-18.15,0

3 Spans=1 M=1 Area=1.377

1 N=9 B=0,333.15 E=756,333.15

LIST=12,63,64,65,66,67,68,69,28

R=0.05,0.5,0.05 S=0,-18.15,0

4 Spans=1 M=1 Area=1.377

1 N=9 B=756,153.15 E=1512,153.15

LIST=19,72,73,74,75,76,77,78,35

R=0.05,0.5,0.05 S=0,-18.15,0

5 Spans=1 M=1 Area=1.377

1 N=9 B=756,267.15 E=1512,267.15

LIST=25,81,82,83,84,85,86,87,39

R=0.05,0.5,0.05 S=0,-18.15,0

6 Spans=1 M=1 Area=1.377

1 N=9 B=756,381.15 E=1512,381.15

LIST=31,90,91,92,93,94,95,96,43

R=0.05,0.5,0.05 S=0,-18.15,0
MESH COMPLETE

STRUCTURE DEFINITION
GRIDS 3 LEVELS 6
GRID AA
  COLUMN 1 E=1,2,1
  COLUMN 2 E=3,4,1
  COLUMN 3 E=5,6,1
GRID BB
  COLUMN 1 E=7,8,1
  COLUMN 2 LIST=9
  COLUMN 3 LIST=10
  COLUMN 4 LIST=11
  COLUMN 5 LIST=12
  COLUMN 6 LIST=13
GRID CC
  COLUMN 1 E=14,15,1
  COLUMN 2 E=16,17,1
  COLUMN 3 E=18,19,1
LEVEL LEV1
  SPAN 1 E=22,27,1
LEVEL LEV2
  SPAN 1 E=52,57,1
LEVEL LEV3
  SPAN 1 E=32,37,1
LEVEL LEV4
  SPAN 1 E=62,67,1
LEVEL LEV5
  SPAN 1 E=42,47,1
LEVEL LEV6
  SPAN 1 E=72,77,1
STRUCTURE COMPLETE

CHANGE STRUCTURE
BUILD N=1,2,1  Day=10
BUILD N=7,8,1  Day=10
BUILD N=14,15,1  Day=10
RERAINTS
  1 R=1,1,1
  13 R=1,1,1
  32 R=1,1,1

CHANGE COMPLETE

SOLVE Day=10  ! OUTPUT

CHANGE STRUCTURE
BUILD N=20,29,1  Day=17
RERAINTS
  4 R=3,3,3  M=3
  16 R=3,3,3  M=15
  35 R=3,3,3  M=34

STRESS N=1 StressTo=216000,216000  Anchor=0.25,0.25
CHANGE COMPLETE

; apply self weight - difference between tributary and effective flange width
LOADING
  L=20,29,1 F=0,-100*5.5*150/1728

SOLVE Day=17
OUTPUT

CHANGE STRUCTURE
  BUILD N=3,4,1 Day=24
  BUILD N=9 Day=24
  RESTRAINTS
    5 R=3,3,3 M=3
    17 R=3,3,3 M=15

CHANGE COMPLETE

SOLVE Day=24 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=50,59,1 Day=31
  RESTRAINTS
    17 R=3,3,0 M=15
    19 R=3,3,0 M=18
    35 R=3,3,3 M=34

  STRESS N=4 StressTo=216000,216000 Anchor=0.25,0.25

CHANGE COMPLETE

; apply self weight - difference between tributary and effective flange width
LOADING
  L=50,59,1 F=0,-100*5.5*150/1728

SOLVE Day=31 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=10 Day=38
  BUILD N=16,17,1 Day=38
  RESTRAINTS
    20 R=3,3,3 M=18
    36 R=3,3,3 M=34

CHANGE COMPLETE

SOLVE Day=38 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=30,39,1 Day=45
  RESTRAINTS
    8 R=3,3,3 M=7
    20 R=3,3,0 M=18
    22 R=3,3,0 M=21
STRESS N=2 StressTo=216000,216000 Anchor=0.25,0.25

CHANGE COMPLETE

; apply selfweight - difference between tributary and effective flange width
LOADING
  L=30,39,1 F=0,-100*5.5*150/1728

SOLVE Day=45 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=5,6,1 Day=52
  BUILD N=11 Day=52
  RESTRAINTS
    9 R=3,3,3 M=7
    23 R=3,3,3 M=21

CHANGE COMPLETE

SOLVE DAY=52 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=60,69,1 Day=59
  RESTRAINTS
    23 R=3,3,0 M=21
    25 R=3,3,0 M=24
    39 R=3,3,3 M=38

STRESS N=5 StressTo=216000,216000 Anchor=0.25,0.25

CHANGE COMPLETE

; apply selfweight - difference between tributary and effective flange width
LOADING
  L=60,69,1 F=0,-100*5.5*150/1728

SOLVE Day=59 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=12 Day=66
  BUILD N=18,19,1 Day=66
  RESTRAINTS
    26 R=3,3,3 M=24
    40 R=3,3,3 M=38

CHANGE COMPLETE

SOLVE DAY=66 ! OUTPUT

CHANGE STRUCTURE
  BUILD N=40,49,1 Day=73
  BUILD N=13 Day=73
  RESTRAINTS
    12 R=3,3,0 M=11
26 R=3,3,0  M=24
28 R=3,3,0  M=27
29 R=3,3,3  M=27

STRESS N=3 StressTo=216000,216000 Anchor=0.25,0.25

CHANGE COMPLETE

; apply selfweight - difference between tributary and effective
flange width
LOADING
L=40,49,1 F=0,-100*5.5*150/1728

SOLVE Day=73 ! OUTPUT

CHANGE STRUCTURE
BUILD N=70,79,1  Day=80

RERAINTS
29 R=3,3,0  M=27
31 R=3,3,0  M=30
43 R=3,3,0  M=42

STRESS N=6 StressTo=216000,216000 Anchor=0.25,0.25

CHANGE COMPLETE

; apply selfweight - difference between tributary and effective
flange width
LOADING
L=70,79,1 F=0,-100*5.5*150/1728

SOLVE Day=80
OUTPUT

SOLVE Day=100
OUTPUT

SOLVE Day=180
OUTPUT

SOLVE Day=365
OUTPUT

SOLVE Day=365*20
OUTPUT

CAPTURE STATUS

LOADING DL ; extract dead loading
DEAD LOAD
SOLVE ! OUTPUT

LOADING PT
PRESTRESSING ; extract prestressing component
SOLVE ! OUTPUT
LOADING LT ; extract long-term effects
LONG TERM
SOLVE ! OUTPUT

LOADING LIVE1
STRUCTURE
  LEVEL LEV1
    SPAN 1
      UNIFORM F=0,-88.33
  LEVEL LEV2
    SPAN 1
      UNIFORM F=0,-88.33
  LEVEL LEV3
    SPAN 1
      UNIFORM F=0,-88.33
  LEVEL LEV4
    SPAN 1
      UNIFORM F=0,-88.33
  LEVEL LEV5
    SPAN 1
      UNIFORM F=0,-88.33
  LEVEL LEV6
    SPAN 1
      UNIFORM F=0,-88.33

SOLVE ! OUTPUT

LOADING LIVE2
PATTERN
  LEVEL LEV1
    SPAN 1
      UNIFORM F=0,-66.25
  LEVEL LEV2
    SPAN 1
      UNIFORM F=0,-66.25
  LEVEL LEV3
    SPAN 1
      UNIFORM F=0,-66.25
  LEVEL LEV4
    SPAN 1
      UNIFORM F=0,-66.25
  LEVEL LEV5
    SPAN 1
      UNIFORM F=0,-66.25
  LEVEL LEV6
    SPAN 1
      UNIFORM F=0,-66.25

SKIP
  LEVEL LEV1 SPANS 1
  LEVEL LEV2 SPANS 0
  LEVEL LEV3 SPANS 1
  LEVEL LEV4 SPANS 0
  LEVEL LEV5 SPANS 1
  LEVEL LEV6 SPANS 0

SKIP
LEVEL LEV1 SPANS 0
LEVEL LEV2 SPANS 1
LEVEL LEV3 SPANS 0
LEVEL LEV4 SPANS 1
LEVEL LEV5 SPANS 0
LEVEL LEV6 SPANS 1

SOLVE ! OUPUT

;;;;.......................... combine solution

COMBINATIONS
   COMBINATION DLPTLT
      1*DL+1*PT+1*LT

STOP