FINAL REPORT

THE DEVELOPMENT OF AN AAIT MODEL OF THE SHORTS SD3-30

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THE SHORTS SD3-30

(1) OBJECTIVE

The objective of this study was to develop an AAIT model of the Shorts SD3-30 aircraft for inclusion in the AAIT aircraft library. This aircraft had previously been drop-tested by the FAA.

The model basically consisted of the crew cabin, fuselage section and the wings, including contributions of the landing gears and the fuel tanks. The model construction was based on the geometrical and physical data available to CIC.

(2) MODEL CONSTRUCTION

A 3-D model was constructed of the Shorts SD3-30 aircraft using the AAIT KRASH program. The model of the aircraft consisted of the main fuselage, wing-struts, wings, landing gear, rudders and rear stabilizer.

The model was constructed in the conventional format and consisted of lumped masses, (with mass-less nodes that modeled rigid connections), beams that represented aircraft structural members and contact springs that defined the crush-characteristics of the aircraft lower-structure in contact with the ground.

The model geometrical and physical data were based on information obtained from the FAA (1, 4), the UK Civil Aviation Authority and the aircraft manufacturers, Shorts of Belfast (2,3).

Note that the available data on the aircraft was limited to basic weight information along with selected engineering drawings that defined the cross-sectional dimensions of key structural members. This information excluded essential data on the elastic limit-loads and the post-failure characteristics of the primary and secondary structures.

(2.1) Mass Properties of Model

Data was extracted from the design information to obtain a distribution of lumped masses that approximated the actual mass distribution of the aircraft. Information on the exact weight and mass moments of inertia of individual components of the structure was not available, with the exception of the aircraft engines and propellers. Consequently, an approximation method had to be used which distributed the known total weight of the aircraft across the lumped mass points iteratively, until a satisfactory balance point was attained on the aircraft model.

The final version of the model consisted of 55 lumped masses. The weight of the model in its empty state, i.e. without fuel, cargo, passengers and crew, was 13, 895 lbs.

(2.2) Beam Properties of Model

The primary structural members of the aircraft were identified from the supplied data. These were idealised as beam elements for the purpose of the model and the elastic-properties of these beams were derived. The elastic section properties consisted of the cross sectional area (A), the torsion constant (XJ) and the second moments of area (IYY, IZZ). Due to unavailability of data, a limited number of beam properties were based on the estimates of similar sections. Ninety five beam elements were used to model the aircraft.

No data was available which defined the location of regions of major failure within the structure. Consequently, the failure characteristics, in terms of failure type (axial, bending, torsional, shear), elastic force limit, post-elastic force/deflection (or moment/rotation) and ultimate yield load were also unknown.

Study of the drop test video highlighted the overall collapse mode of the aircraft. This was used to identify the location of the major collapse zones on the aircraft structure. From this, the areas of major collapse were identified. These included plastic bending moments for wing roots and at both sides of each engine attachment to the wing. In addition, plastic bending moments were programmed in for the fuselage roof longitudinal, both in-front and aft of the fuel tanks. Axial collapse of all the fuselage upright beams was incorporated into the model. As data was unavailable denoting these failure loads, the following assumptions were made;

FAILURE POSITION	FAILURE TYPE	MAGNITUDE
Wing Root	Bending Moment	N/K
Engine Inner	Bending Moment	N/K
Engine Outer	Bending Moment	N/K
Fusl Roof Longitudinal	Bending Moment	N/K
Fusl Uprights	Axial Collapse	N/K

(2.3) Contact Springs

In total there were 27 contact springs in the model. These were positioned to define interaction between the fuselage floor, landing gear and the wing tips with the ground.

The spring characteristics for the landing gear were extracted from the manufacturer's data. Critically, no data was available for the crush-characteristics of the fuselage floor.

In the absence of appropriate information, data from the vertical drop test of a Beechcraft 1900C (Ref. 4) was used to represent the fuselage floor, vertical crush response.

(3) SIMULATION RESULTS

The completed Shorts SD3-30 model was used to simulate the 30 feet per second drop test conducted by the FAA. Note that the landing gear was removed from the aircraft prior to the drop test and this modification was also applied to the model for this simulation run only. The simulation was performed for 200 msec. The deformed structure exhibited collapse in the wing and the fuselage centre section.

Figures AA to BB show the model in terms of location of lumped mass points, rigid connections, beams and contact springs. The deformed state of the model at 200 milliseconds, when used to simulate the 30 feet per second drop test, is shown in Figure CC. Also depicted is additional information, such as accelerations produced at various locations of the aircraft.

(4) REFERENCES

(1) Shorts SD3-30 Repair Manual and General Data (1-00 to 1-90) Provided by FAA.

(2) “Report No. 2, SD3-30 Weights”, Bombardier Aerospace, Shorts Technical Engineering Department, Belfast, October 1975.

(3) “Report No. 4, Basic Structural Data”, Bombardier Aerospace, Shorts Technical Engineering Department, Belfast, September 1975.

(4) McGuire RJ, Vu T; “Vertical Drop Test of a Beechcraft 1900C Airliner”, Final Report DOT/FAA/AR-96/119, Federal Aviation Administration, Airworthiness Assistance R&D Branch, William J. Hughes Technical Centre, Atlantic City International Airport, NJ, USA, May 1998.

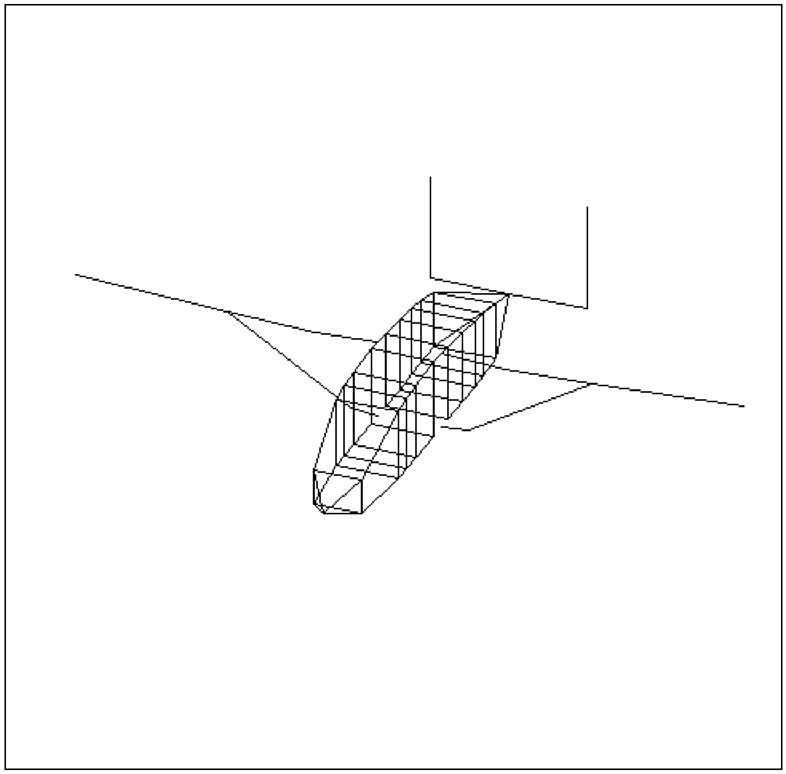

Figure 1   Baseline Model - Overall View

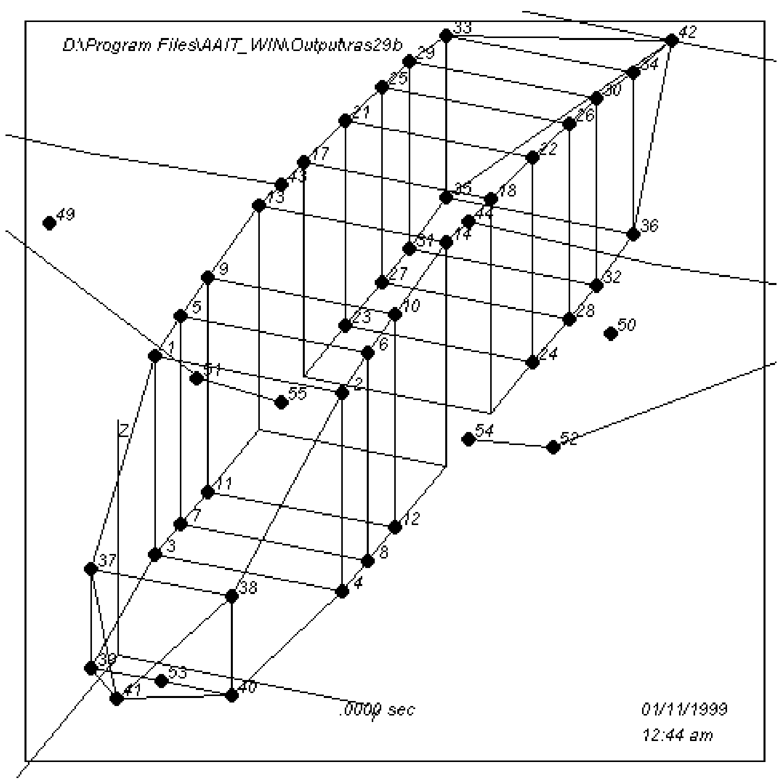

Figure 2   Baseline Model - Lumped Mass Points

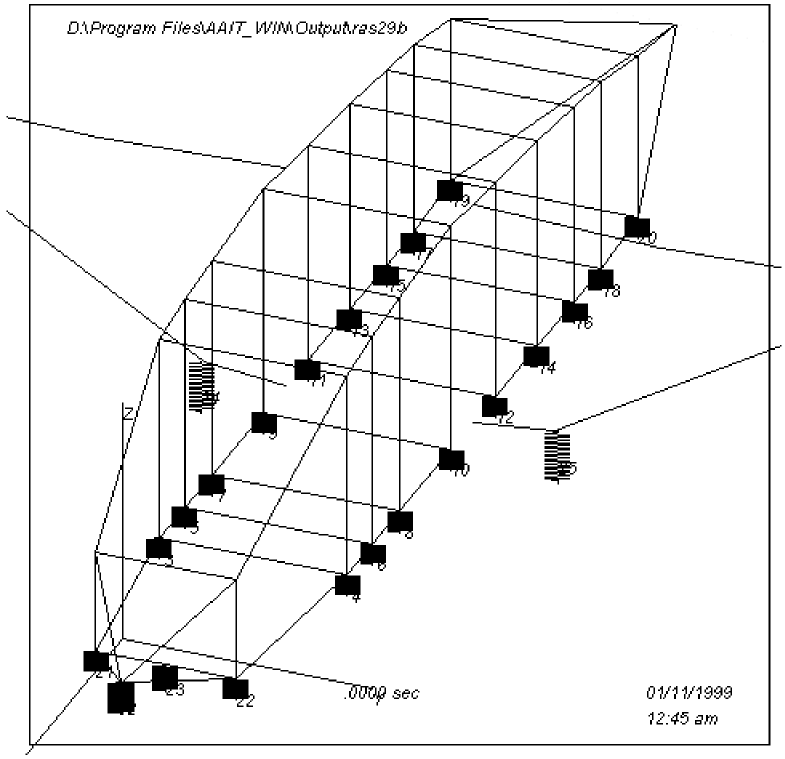

Figure 3 Baseline Model - Spring Elements

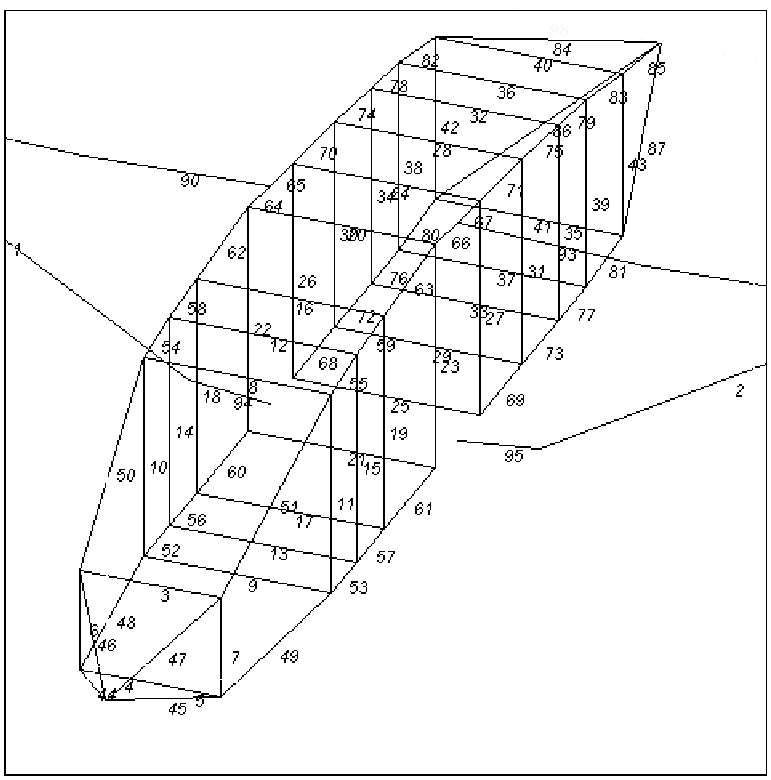

Figure 4 Baseline Model - Beam Numbers

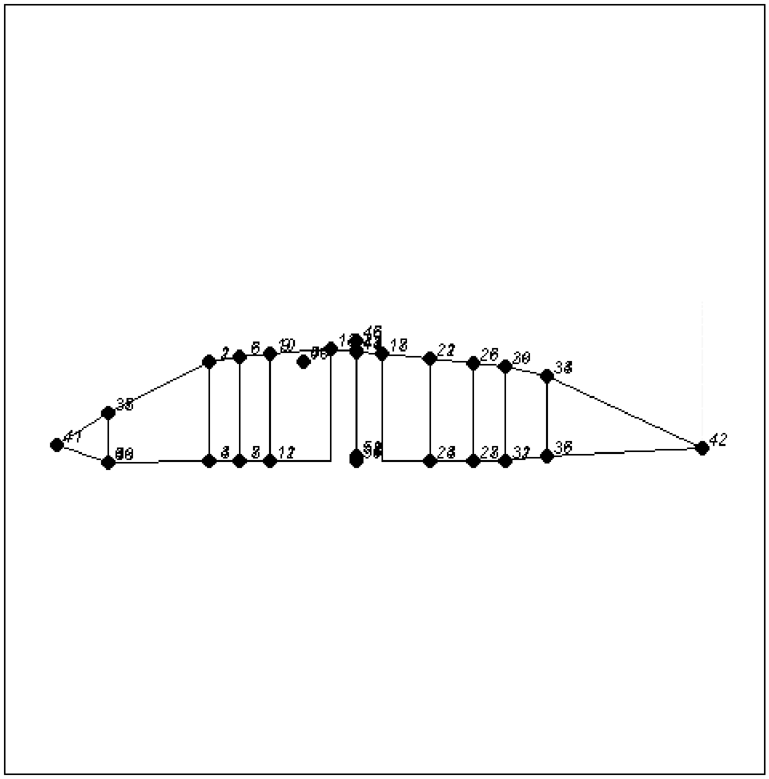

Figure 5   Baseline Model - Side View - Undeformed

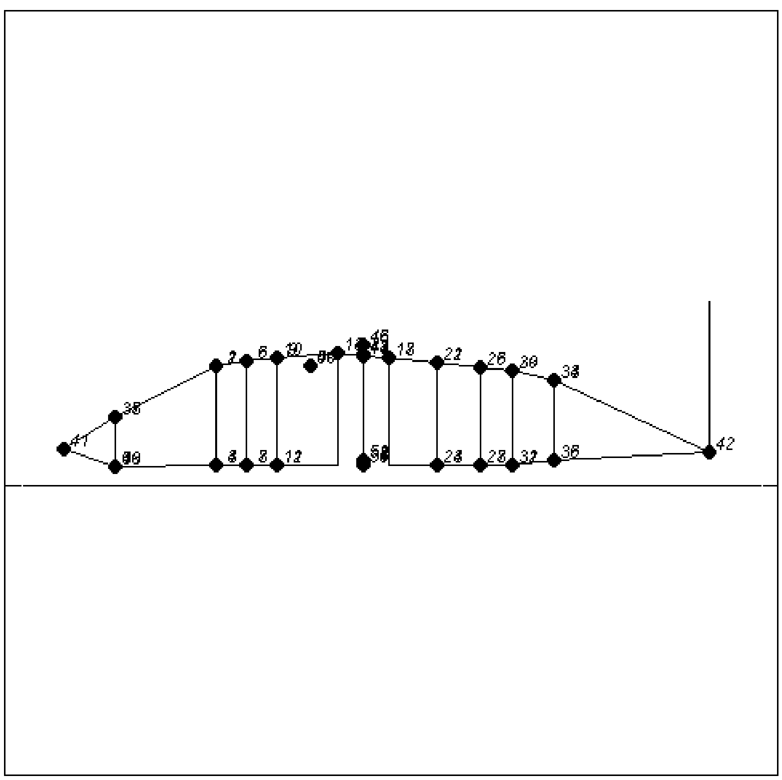

Figure 6   Baseline Model - Side View - Undeformed with Ground

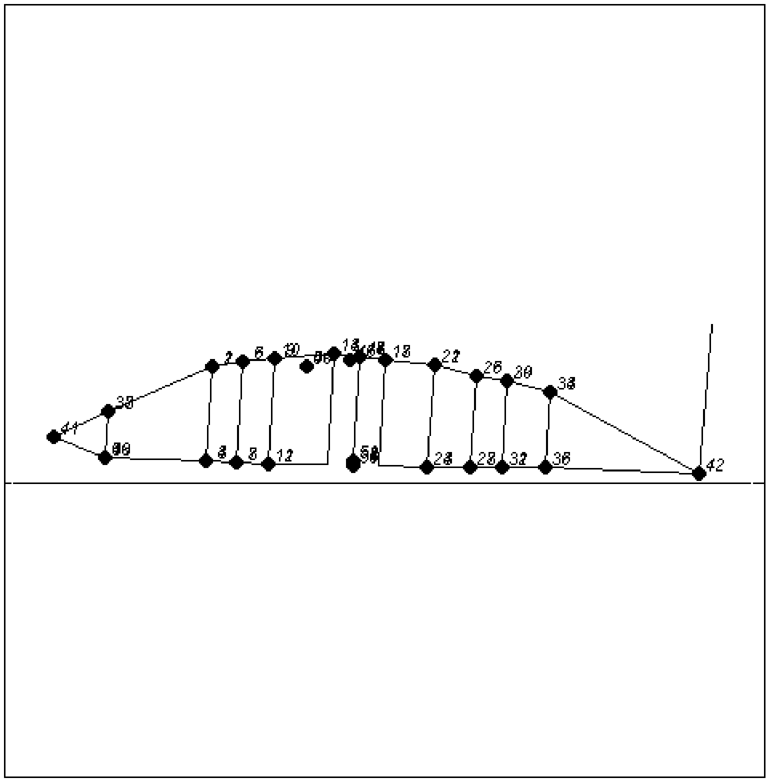

Figure 7   Baseline Model - Side View - deformed with Ground

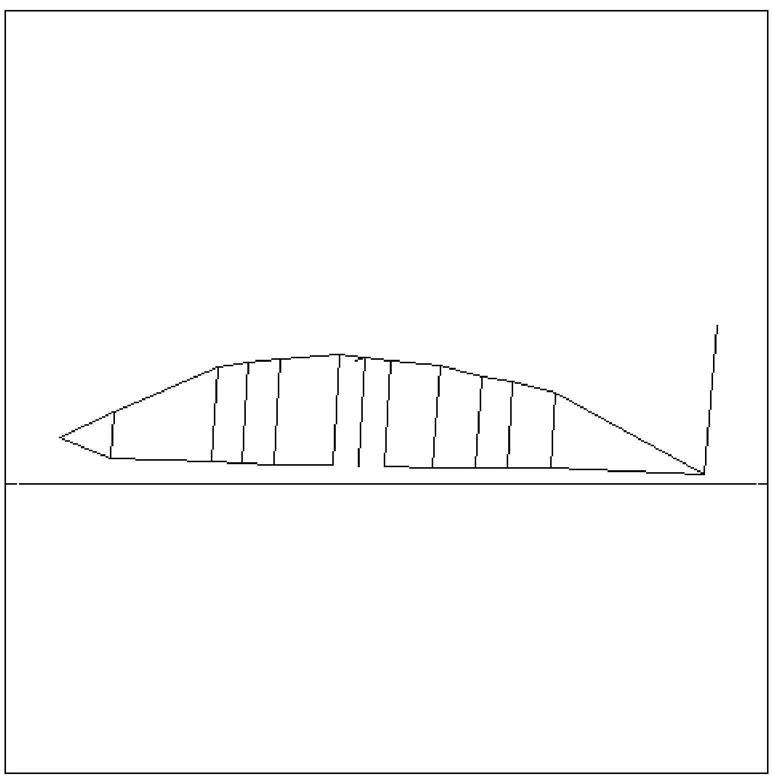

Figure 8   Baseline Model - Side View - deformed with Ground

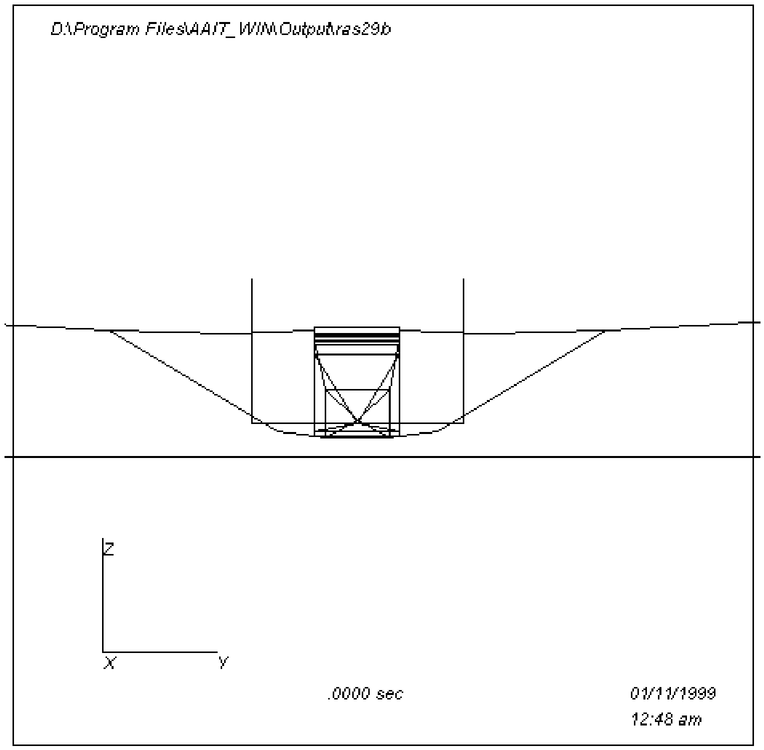

Figure 9   Baseline Model - Front View - undeformed with Ground

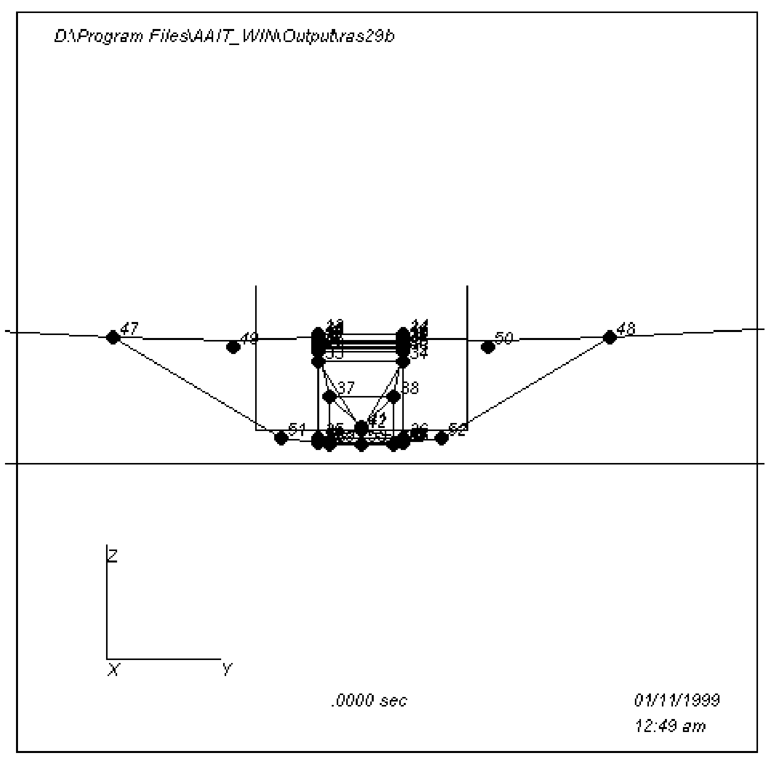

Figure 10   Baseline Model - Front View - undeformed with Ground

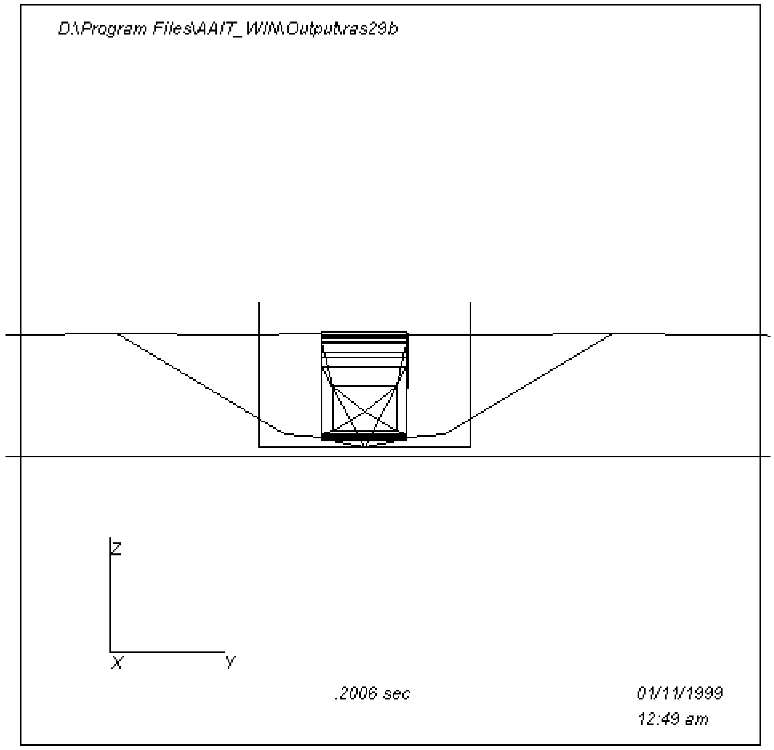

Figure11   Baseline Model - Front View - deformed with Ground

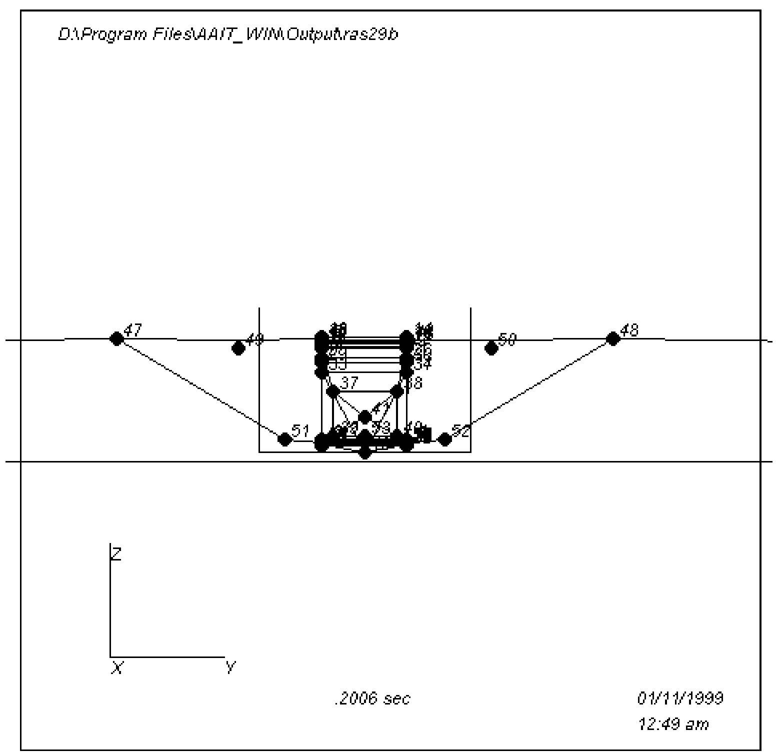

Figure 12   Baseline Model - Front View - deformed with Ground