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VARIATIONS IN AIRCRAFT SHELTER COSTS

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VARIATIONS IN AIRCRAFT SHELTER COSTS

1. Variations in costs of structures acting primarily in flexure.

The last paragraph of D-3198 states that "for pressures not greater than 250 psi one may safely assume that the cost of shelters of similar geometry will vary approximately as the square root of the critical pressures." Thus, one can estimate the cost of a protective structure designed to withstand 200 psi at approximately 1.414 times the cost of a 100 psi structure of identical design.

This square root rule is a convenient rule, particularly for planning and budgeting purpose, as it allows the costing of a range of protective capabilities on the basis of a single design. The rule is derived from a number of past studies in the behavior of beams under uniformly distributed dynamic loads and appears valid for entire structures as well as single elements under blast loads. Its application, however, should be limited to structures primarily acting in flexure under dynamic load and to the elements so loaded directly or indirectly. In addition, the range of blast pressures over which the rule is applied should not be so great as to require radical changes in structural characteristics in the various designs under consideration.

The validity of the square root rule is further confirmed by the engineering and cost studies of a B-52 shelter undertaken for the Economics Division.

The shelter is of fairly simple geometry with relatively short spans acting in flexure and the design peak pressures range from 50 to 200 psi.

In the table below are shown the costs of the proposed structures, the ratios of these costs and the square root of the design blast load ratios. Two structural systems are shown, the first of reinforced concrete with steel roof and the second entirely of structural steel. The costs shown are exclusive of fixed costs¹ covering excavation, form work and mechanical equipment such as lifts, motors, etc. The costs also exclude contingency, overhead, and profit, the total of which may run as high as 25 percent.

Blast Pressure PSI	Square Root Of Pressure Ratio	Cost of Reinforced Concrete and Steel Roofing in 000's	Cost Ratios	Cost of Steel in 000's	Cost Ratios
50	1.00	567	1.00	648	1.00
100	1.414	798	1.41	898	1.385
150	1.732	1,016	1.79	1,141	1.765
200	2.00	1,212	2.15	1,299	2.00

Barring errors, the agreement between the cost ratios and the square root of the blast load ratios is very good for either structural system.

2. Variations in cost of structures acting primarily in compression or tension.

For structures such as domes, arches or catenaries which under dynamic loads act primarily in compression or tension, the relationship of costs to

¹\$192,000 for the mixed construction and \$187,000 for the steel design.

blast loads is quite different. In connection with a WADC research contract, the American Machine and Foundry Company studied a number of reinforced concrete domes suitable for aircraft protective hangars and for blast loads of 50, 200 and 500 psi. The estimated costs of these designs were published in D-3347.

In the table below are listed the costs per square foot of these domes according to diameters and design pressures. The average cost ratio is equal to .75 times the design pressure ratio. The small deviations from this average which appear to be a function of diameter should be ignored although they can be rationalized on the basis of structural characteristics.

Diameter	%	50 Psi Design		200 Psi Design		500 Psi Design	
		\$Cost Per Sq. Ft.	%	\$Cost Per Sq. Ft.	%	\$Cost Per Sq. Ft.	%
132'		14	100	48	340	115	820
200'		20	100	63	315	150	750
280'		27.5	100	84	306	(196)	715
380'		35	100	103	300	(236)	680
Average					315		741
132'	100	14	100	48	100	115	100
200'	152	20	143	63	132	150	130
280'	214	27.5	196	84	175	(196)	170
380'	288	35	250	103	214	(236)	205

(Figures in parenthesis are estimates by the authors and not by AMF)

3. B-47 and B-52 Shelters.

The 55 psi B-47 shelters proposed by the JADB in 1953 and the 50 psi B-52 shelter developed for the Economics Division are similar in design concept. Both consist of a pit whose plan follows closely the contour of the aircraft and both are equipped with movable closure slabs. However, the two proposals exhibit differences of detail, particularly in the lift and rolling mechanism.

The gross areas of these shelters are 6000 and 11,700 square feet for the B-47 and B-52 respectively. The cost of the B-47 shelter is estimated at 527,000 dollars (J. J. O'Sullivan, D(L) 1807, 12 August 1953) or 88 dollars per square foot. The estimate of the B-52 shelter totals 950,000 dollars or 81.0 dollars per square foot, if one includes the same 25% provision for contingency overhead and profit over structural and fixed costs which was used in the costing of the B-47 shelter.

The difference in cost per square foot amounts to 8 percent and is within the limits experienced in actual bid practice. On the basis of this limited sample it seems that the unit costs of shelters of similar design concept, geometry and resistance will tend to remain constant over a range of sizes unless the basic design parameters are substantially modified.