94 Doc f
Preliminary Draft Report on "Effects of the 4,000 pound bomb on Japanese Targets"

RESTRICTED

UNITED STATES STRATEGIC BOMBING SURVEY

(PACIFIC)

PHYSICAL DAMAGE DIVISION

REPORT 72

EFFECTS OF THE FOUR THOUSAND-POUND BOMB ON JAPANESE TARGETS

A Report on Five Incidents

Over-all Dates of survey: 19 October - 16 November 1945

II

UNITED STATES STRATEGIC BOMBING SURVEY

The United States Strategic Bombing Survey was established by the Secretary of War on 3 November 1944, at the direction of President Roosevelt, to study the effects of strategic bombing on the German war economy and on the capacity and will of the German people to resist. Several hundred German plants and representative urban areas were closely examined, many volumes of statistical and documentary material were analyzed, and more than 230 detailed reports were published.

On 15 August 1945, President Truman requested that the Survey continue its work in Japan. The Japanese Survey differed from the European in that its purpose was to study the role of airpower in the war in the Pacific including all types of air attack and to submit reports both to the Secretary of War and the Secretary of the Navy.

Key personnel were deployed from Europe, assembled in Washington and Guam, and moved to Tokyo early in October 1945. Shortly thereafter, field teams of the Survey began a study of Japanese industries, plants, urban areas, morale, military operations, and logistics.

The Survey has given considerable emphasis to a study of the effects of the atomic bombs. Two large teams of scientists and engineers who spent two months at Nagasaki and Hiroshima have prepared a report on the subject. In addition, some 200 detailed reports on other phases of the study have been written and more than 700 interrogations of major Japanese officials and industrialists were made.

In Japan, as in Europe, the Survey has been responsible for the recovery, preservation, and translation of many important documents of military, industrial, economic, and social significance. The information contained in them has not only been useful to the purposes of the Survey but will also furnish valuable data for other studies. Arrangements have been made to turn over the files of the Survey to the Central Intelligence Agency where the materials will be available for further examination and distribution to its component State, War, and Navy Intelligence organizations.

The officers of the Survey for the Japanese phase were:

Franklin D'Olier, Chairman
Paul H. Nitze, Vice Chairman
Henry C. Alexander, Vice Chairman
Harry L. Bowman
Theodore P. Wright
Fred Searles
Col. Frank McNamee
Kenneth Galbraith
Monroe Spaght
Rensis Likert
Dr. Louis R. Thompson, Director

This present report was prepared by the Physical Damage Division of the Survey. The Division officers for the Japanese phase were:

Harry L. Bowman, Director
Lt. Col. Charles R. Chapman, Chief
Maj. Leland N. Stead, Executive

PDD REPORT 72

UNITED STATES STRATEGIC BOMBING SURVEY

(PACIFIC)

PHYSICAL DAMAGE DIVISION

REPORT 72

EFFECTS OF THE FOUR THOUSAND POUND BOMB ON JAPANESE TARGETS

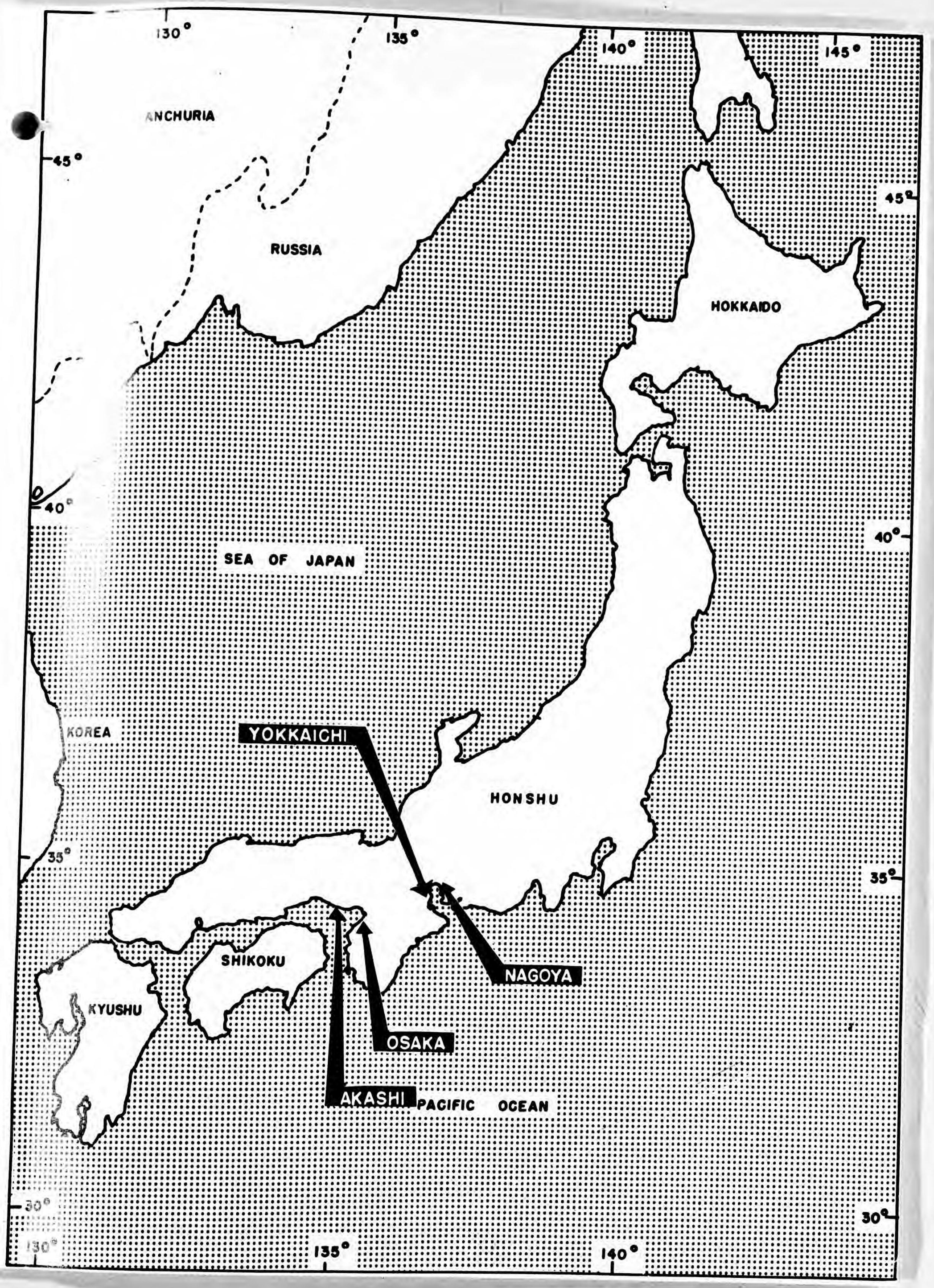
A Report on Five Incidents

Over-all Dates of Survey: 19 October - 16 November 1945

PDD REPORT 72

CONTENTS

Note: A table of contents for each Part is provided in the front thereof.


130°
135°
140°
145°
45°
ANCHURIA
RUSSIA
HOKKAIDO
40°
SEA OF JAPAN
KOREA
YOKKAICHI
HONSHU
35°
SHIKOKU
NAGOYA
KYUSHU
OSAKA
AKASHI
PACIFIC OCEAN
30°

SECTION I

INTRODUCTION

INTRODUCTION

1. **The Weapon.** This report comprises studies on the use and effectiveness against Japanese industrial targets of the M56, 4,000-pound, light-case, high-explosive bomb, equipped with instantaneous-nose and non-delay-tail fuzes.

2. **The Targets.** The targets selected for study, all of which had been subjected to attacks by this weapon, consisted of aircraft engine and assembly plants, a light-metals plant, an oil refinery and fuel depot, and a combined aircraft and munitions plant.

3. **Types of Structures.** Structures in the target areas varied according to plant type and use. In general, they were light, steel-frame buildings with corrugated-asbestos or sheet-iron walls and roofs; or heavy, steel-frame, mill-type structures, some of which had overhead crane runways forming integral parts of the construction; or steel and reinforced-concrete buildings, including a few of earthquake-resistant design; and a comparatively small number of wooden structures used as offices and auxiliary buildings. Each of the incident reports lists the buildings affected by the attacks, describes their construction, and classifies the high-explosive and fire vulnerability of each.

4. **Other Installations.** Other installations are discussed in this report, such as steel tanks, stacks, refinery structures, boiler houses, and plant utilities.

5. **Other Attacks.** Each of the targets was subjected to attacks by weapons other than the 4,000-pound bomb, but those strikes resulted in relatively minor damage. No effort has been made to discuss their

effect in detail; such information that is included is to permit a general comparison of effects and to provide an explanation of the presence of damage not caused by 4,000-pound bombs.

6. Photo Interpretation

a. In some parts of this report, results of photo interpretation are compared with the findings of the field team. Discrepancies between the two were accounted for, in some instances, by the discovery of hidden damage in the target area, such as damage to sidewalls and interiors, which would not have been visible on aerial photographs.

b. Plant production was often overestimated by photo interpreters who apparently based their findings on the possible capacity of plant installations indicated by size and construction, whereas actual production was affected by many factors which could not have been visibly judged.

SECTION II
SUMMARY
CONCLUSIONS

SUMMARY

1. **Steel-Frame Buildings.** The 4,000-pound bomb was especially effective in producing large-scale damage to steel-frame, mill-type buildings. The cutting, knocking out, or displacing of interior columns resulted in collapse of supporting beams and connected framing, which, in turn, aided in spreading damage and distortion throughout wide areas. Buildings with long-span trusses were subjected to widespread structural damage because of column removal. Near-misses caused distortion of columns, damage to roof steel, and superficial damage, such as wall and roof stripping, over extensive areas. Explosions in roof steel generally created wider damage than floor bursts which occurred usually in the absence of roof covering as a result of previous attacks.

2. **Reinforced-Concrete Buildings.** This type of building suffered heavy damage to roof and floor slabs in the immediate vicinity of the bomb burst. At greater distances the blast effect damaged members and displaced slabs. Interior bursts blew out walls and exterior columns.

3. **Blast Walls.** Brick blast walls generally failed to withstand the blast of near-by detonations and became debris themselves often causing damage to contents, but in the cases where they were not demolished they did limit damage from fragmentation and flying debris.

4. **Fire.** Fire damage to combustible structures and contents was usually a secondary result of 4,000-pound-bomb attacks, and was generally limited in scope, so that plant fire-fighting efforts were effective in preventing widespread damage. In one plant, however, fire affected practically all combustible buildings and contents in the attack area,

and, in addition, contributed to the over-all structural damage of non-combustible structures by warping and distorting steel members.

5. Plant Utilities. Plant utilities were damaged to some degree or put out of service entirely in almost every instance. It was seldom, however, that such damage was sufficiently extensive to preclude prompt restoration of at least a part of the services for limited operations.

6. Machine Tools. Damage to machine tools resulted from blast, fragmentation, building collapse, falling debris and, occasionally, from fire. In plants where salvage and repair operations had not been promptly initiated, or where protective coverings had not been provided, additional damage to tools and equipment occurred through exposure to the elements. Fragmentation was one of the most effective agents in producing damage to machinery. Falling structural members and debris accounted for some damage, but, in the main, material of this nature lacked sufficient force to produce heavy damage. It was generally observed that machines in close proximity to the point of detonation suffered heavy damage, but the effects from any one burst were not widespread.

7. Production. Products manufactured by the plants discussed in this report were critical items needed by Japan's hard-pressed war machine, and production suffered seriously as a result of the 4,000-pound-bomb attacks. In at least 3 of the 5 plants studied, production had been either drastically cut or virtually stopped as a result of high-explosive hits on vital area, of fire damage, or of inability to utilize machines which, although undamaged, had been rendered

inoperative by debris. In one instance, however, the reduction in production was also affected by earthquake damage, which occurred prior to the attack, and by manufacturing difficulties.

8. General

a. It is apparent that the 4,000-pound bomb was an excellent choice of weapon against the types of plants selected as targets. Its effectiveness against steel-frame buildings is graphically illustrated by the following text and accompanying photographs. The degree of its superiority over other types of demolition bombs becomes more conclusive as the weight of target construction increases.

b. Evaluation of the bomb's effects on machine tools and plant equipment, however, indicates that the over-all results were not particularly outstanding compared with its potential power. This type of damage was not sufficiently widespread, and the damage per ton of bomb was too low to consider the weapon to be an efficient agent in this respect.

C. Mean Areas of Effectiveness (MAE's) have been computed for the 4,000-pound bomb, and they will be found in P.D.D Report 76, the over-all report of this Division. A comparison of the MAE's for this weapon with those of other bombs discussed will indicate its relative effectiveness.

SECTION III

REFERENCE TABLES

III REFERENCE TABLES

For ready reference the following tables are included herewith:

1. Definitions of types of damage and terms applied thereto.
2. Building Types or Classifications - Table A
3. High-Explosive Vulnerability Classes - Table B
4. Fire Classification - Buildings and Contents

TYPES OF DAMAGE

Damage to Buildings, Industrial and Domestic

a. Structural: damage to principal load-carrying members (trusses, beams, columns, load-bearing walls, floor slabs in multi-story buildings) requiring replacement or external support during repairs. Light members such as purlins and rafters are not included.

b. Superficial: damage to purlins and other light members, stripping of roofing and non-load-bearing exterior walls. Damage to glass and interior partitions not included.

Damage to Machinery, Utilities and Equipment

a. Total: not worth repair.

b. Heavy: requiring repair beyond capacity of normal maintenance staff; usually returned to manufacturer.

c. Slight: requiring repair within capacity of normal maintenance staff.

Damage to Contents Other than Machinery and Equipment

a. Total: not usable

b. Other: usable if reprocessed or repaired.

BUILDING TYPES OR CLASSIFICATIONS

(Tables A and B from Joint Target Group)

TABLE A

GROUP		TYPE SYMBOL	DESCRIPTION
A. Single-story, no traveling cranes, spans generally less than 75 ft, heights at eaves generally less than 25 ft, area of 10,000 sq ft or more	1. With saw-tooth roofs	A1.1	All buildings of this group with saw-tooth roofs other than those included in Types A1.2, A1.3, and A1.4
		A1.2	Frame and roof slab of monolithic reinforced concrete
		A1.3	Exposed top chords of trusses
		A1.4	Stressed-skin type of reinforced concrete (e.g. Zeiss Dywidag)

GROUP		TYPE SYMBOL	DESCRIPTION
	2. Without saw-tooth roofs	A2.1	Simple beam and column
		A2.2	Arches and rigid frames
		A2.3	Truss construction
		A2.4	Frame and roof slab of monolithic reinforced concrete
		A2.5	Stressed-skin type including concrete shell
B. Single-story with traveling cranes; any length of span; area of 10,000 sq ft or more	1. Bldgs housing heavy cranes	B1	Buildings containing runways for heavy cranes (capacity 25 tons or more); height at eaves generally more than 30 ft.
	2. Bldgs housing light cranes	B2	All buildings in this group other than those in B1
C. Single-story; no traveling crane runways; spans greater than 75 ft; height at eaves generally greater than 25 ft; area of 10,000 sq ft or more	1. Main frame members in two directions	C1.1	Roof trusses supported along one side of building by long span trusses and along other side by columns. Permits large door along one side and at ends
		C1.2	Continuous trusses in one or two directions; long span in one direction, supported by columns or exterior walls and by internal columns.
		C1.3	Exposed chord saw-tooth roof buildings; exposed chord trusses supporting major size trusses at 90°. One or both truss systems may be of long span.
		C1.4	Diamond mesh arch.
	2. Main frame members in one direction only	C2.1	Long-span arches, individually supported along sides of building. May be arranged

GROUP		TYPE SYMBOL	DESCRIPTION
			in multiple spans joined along side.
		C2.2	Long-span, triangular or bowstring trusses, individually supported by columns at sides of building. May be arranged in multiple spans joined along side, using common columns. Roof pitch exceeds 2 in 10.
		C2.3	Long-span trusses, top cord of pitch 2 in 10 or less, including exposed cord saw-tooth roofs, individually supported by columns along sides of building. May be arranged in multiple spans using common columns or may be continuous over internal columns.
	3. Shell-type construction	C3	Stressed-skin including concrete shell construction.
D. All single-story buildings of less than 10,000 sq ft plan area		D	This type covers all single-story industrial buildings, regardless of type of construction if under 10,000 sq ft in plan area.
E. Multi-story frame buildings.		E1	Earthquake-resistant; extremely heavy steel reinforced-concrete, multi-story construction, designed to resist heavy lateral loads.
		E2	Structures in this group other than those in E1

GROUP		TYPE SYMBOL	DESCRIPTION
F. Multi-story, wall-bearing buildings. (May have internal columns.)		F1	Earthquake-resistant, wall-bearing construction. (Walls of reinforced brick concrete, or very massive masonry.)
		F2	Structures in this group other than those in F1.
S. Special Structures		S	Coke ovens, test cells, fuel storage, boilers in power plants, etc.

HE VULNERABILITY CLASSES

TABLE B

HE Vulnerability Class	Substructural Groups (Symbols refer to Table A)
V1	E1
V2	B1, B2
V3	E2, F1
V3A	F2
V4	A1.1, A1.2, A1.3, A2.1, A2.2, A2.3, A2.4, D
V4A	C1.2, C1.3, C1.4, C2.3
V5	A1.4, A2.5 C1.1 C2.1, C2.2 C3

FIRE CLASSIFICATION - BUILDINGS AND CONTENTS

C - Combustible: Buildings whose roofs and/or walls are constructed of combustible material. The floors (except the ground floor) are required to be of similar construction. Wood-frame buildings with noncombustible sheeting on roof and/or walls are also included in "combustible" class.

N - Noncombustible: Buildings which have no significant amount of combustible material in the structure, but whose structure is susceptible to damage by fire in the contents. An example of this type is a building with exposed steel members which may be warped irreparably by the heat of a fire. Roofs of this type are: Corrugated asbestos, corrugated iron, pre-cast or pour-in-place cement or gypsum on exposed steel, and reinforced concrete 2 1/2-inches thick or less.

R - Fire-resistive: Buildings which have no significant amount of combustible material in the structure and which will withstand all but the most intense fire without structural damage. Roofs and floors (other than ground) should be of concrete more than 2 1/2-inches thick, and the steel frame should be protected and not subject to ordinary fire damage.

C & N, N & R or C & R used where above types are combined in a single fire division.

SECTION IV

INCIDENT REPORTS

PARTS 1 - 5, INCLUSIVE

PDD REPORT 72
PART 1

UNITED STATES STRATEGIC BOMBING SURVEY

(PACIFIC)

PHYSICAL DAMAGE DIVISION

REPORT 72

SECTION IV

PART 1

Effects of the 4,000-pound Bombs Dropped on the Plant of the Kawasaki Aircraft Company, Akashi, Japan

Target 90.25 - 1547

Dates of Survey: 19 October - 3 November 1945

PDD REPORT 72
PART 1

CONTENTS

I OBJECT OF STUDY

The object of this study was to determine the effect of 4,000-pound bombs (M56) on steel- and reinforced-concrete buildings found at the Kawasaki Aircraft Company, Akashi, Japan.

II SUMMARY

1. The Kawasaki Aircraft Company's Plant at Akashi, 34° 39' N - 134° 57' E, Japan, consisted of a total of 163 acres and was roughly rectangular in shape. Buildings (steel-frame, wooden, and reinforced-concrete) covered 69.8 acres or 43 per cent of the total area. This installation produced aircraft engines of the liquid- and air-cooled types, as well as single- and two-seater-fighter fuselages. The company as a whole, with all plants considered, was responsible for 25 per cent of the engines used in all Japanese army combat aircraft. The Akashi plant, in addition to its production functions, performed tests on engines manufactured at all other Kawasaki holdings.

2. B-29 aircraft of the Twentieth Air Force attacked the Kawasaki Akashi plant four times as a primary target. The first attack on 19 January 1945 was accomplished with 500-pound, general-purpose AN-M64 bombs fuzed 0.10 second nose and 0.025 second tail. (Only 4,000-pound, light case bombs will be covered in detail by this report.) The second, third, and fourth strikes were made on 9, 22, and 26 June 1945, respectively, with 4,000-pound light-case M56 bombs fuzed instantaneous nose and non-delay tail. The three 4,000-pound attacks varied in altitude of release from 26,200 feet to 16,000 feet. The target was hit as a result of these attacks with a total of 46 bombs, of which 24 hit

buildings and 22 exploded in the open. These 46 bombs amounted to a total of 92 tons (Bomb Plot, Figure 5). The strike of 9 June 1945 was by radar; that of 22 June was visual; and that of 26 June was combination visual and radar.

3. Photo Intelligence estimated that the 4,000-pound bomb structural damage to five partly destroyed buildings was 237,500 square feet or 28.2 per cent of the estimated 842,400 square feet of original roof area. Field survey showed that of the 779,200 square feet original roof area of those five buildings, 202,600 square feet or 26 per cent was damaged. For details of Photo Intelligence data refer to Table H. All structures within the plant were superficially damaged. ~~In making this survey, Field Team 3 assessed as structurally damaged all structures or parts of structures which were rendered inadequate, unsafe or unusable for the purpose for which they were designed. Superficial damage was considered as that damage which occurred to windows, curtain walls, roofs, and other non-structural parts of buildings.~~

III GENERAL INFORMATION

1. The study of the Kawasaki Aircraft Company, Akashi, Japan, was begun on 19 October 1945 and completed on 3 November 1945.

2. Composition of Field Team 3:

Major H. W. McCord	Team Chief
Major W. N. Dillin	Ordnance Officer
Major R. B. Wilson	Structural Engineer
Capt P. Elliott	Structural Engineer
Lieut J. E. Bennett, USNR	Structural Engineer

Lieut P. Casamajor, USNR	Photo Interpreter
1st Lt F. A. Bellucci	Ordnance Officer
Mr. C. K. Parker	Interpreter
Sgt M. Calvin	Photographer
Bosn 1/c J. B. Daniels, USNR	Draftsman
Y 3/c H. Albrecht, USNR	Clerk
S 2/c C. L. Hirrel, Jr, USNR	Draftsman

3. [redacted] Data obtained were from Twentieth Air Force operational reports, plant records, personal interviews, and visual observation.

4. Bomb plots furnished by plant officials were inaccurate and resulted in preparation of new plots by the ordnance members of this team.

5. The target area had not been disturbed and was under U. S. military guard.

IV THE TARGET

1. Official Personnel. Mr. Shugira was technical director of the company and held the retired rank of Lieutenant General in the Japanese Army. Mr. Komoda, the architectural engineer for the firm, was a graduate of the Tokyo University and had traveled in the United States for several months during the year of 1929. All engineering data on buildings, such as live loads, wind loads, [redacted], and [redacted] were furnished by Mr. Komoda, while Mr. Shugira supplied general information and production and operation details.

2. Location. Target 90.25-1547 was about two miles west of the city of Akashi and consisted of the Akashi Aircraft Engine Plant

(Akashi Hatsudaki Kojo) and the Akashi (Airplane) Fuselage Plant (Akashi Kitai Kojo). Both plants were holdings of the Kawasaki Aircraft Company (Kawasaki Kokuki Kabushiki, Kaisha) and a consolidation of the two was begun in September, 1940. At that time the Aircraft Engine Plant was moved from Kobe to Akashi, and in November 1940 the (Airplane) Fuselage Plant was moved from Gifu City to Akashi. By the end of 1940 the consolidation had been completed and production was under way.

3. Building Data. Prior to the 4,000-pound-bomb air attacks, buildings covered 69.8 of the total 163 acres or 43 per cent of the plant which was roughly in the shape of a rectangle (General Layout and Photo Plot, Figure 6).

a. The structures at this target were of three types: wooden, steel-frame, and reinforced-concrete. In general, concrete buildings were used for administration and storage; steel buildings for sub assembly, assembly and work shops; wooden buildings [redacted] for living quarters, bath houses, and other needs connected with the housing and care of personnel. The steel-frame and reinforced-concrete buildings were adequate in design although the quality of material and construction in the reinforced-concrete buildings was poor. Material and construction of wooden buildings was also poor. Figures 3 and 4 show construction of typical steel and concrete buildings.

b. In conversations with plant officials it was learned that all large structures were constructed to withstand earthquake

shocks.* In addition the following general design criteria were furnished:

(1) Live load on roofs - 6.15 pounds per square foot.

(2) Live load on office building floors - 61.5 pounds per square foot.

(3) Wind load, vertical surfaces - 20.4 pounds per square foot.

(4) Tensile and compressive working stress of structural steel - 17,000 pounds per square inch.

(5) Ultimate tensile stress of structural steel - 52,700 pounds per square inch.

(6) Design compressive strength of concrete - 640 pounds per square inch.

(7) Ultimate compressive strength of concrete after 28 days - 1,422 pounds to 2,148 pounds per square inch.

* Earthquake formula:

$K = \frac{F}{W} = \frac{a}{g}$ 0.1 --- Where W is the weight of any part

F (=KW) is the horizontal force assumed acting on the part due to the earthquake

g is the accelration due to the force of the earthquake

g is the acceleration due to gravity

(8) Unit cost of steel erected - 560 yen per ton (Yen @ 23.8 cents).

(9) Unit cost of reinforced concrete in place - 256 yen per cubic yard.

4. Capital. The Kawasaki Aircraft Company, a joint stock company with a nominal capital of 300,000,000 yen, was incorporated in 1937. It had a paid up capital of 150,000,000 yen, based on the pre-war value for the yen of 23.8 cents.

5. Products. This plant manufactured aircraft engines, both liquid and air cooled, and aircraft fuselages of the two-seated Nick fighter (Ki-45) and single-seater Randy night fighter (Ki-102) types. The highest monthly production of engines was ~~450~~ 450 in ~~October~~ November 1944 (Table A) and dropped to 410 just prior to the first U. S. air assault on this plant early in January, 1945. Fuselage production went from a high of 119 in August 1944 to a pre-attack low of 50 in December, 1944 (Table B).

a. The Akashi plant, most important of Kawasaki factories, together with other plants turned out 25 per cent of the engines used in all Japanese army combat aircraft. This was indicative of its importance as a military target.

b. Engines used in the two types of fighter fuselages produced at Akashi came from the Mitsubishi Plant in Nagoya.

c. Production for both engines and fuselages was considerably decreased during the year of 1945 as indicated in Table C. A primary function of the Akashi Plant was to test engines produced in all

(8) Unit cost of steel erected - 560 yen per ton (Yen @ 23.8 cents).

(9) Unit cost of reinforced concrete in place - 256 yen per cubic yard.

4. Capital. The Kawasaki Aircraft Company, a joint stock company with a nominal capital of 300,000,000 yen, was incorporated in 1937. It had a paid up capital of 150,000,000 yen, based on the pre-war value for the yen of 23.8 cents.

5. Products. This plant manufactured aircraft engines, both liquid and air cooled, and aircraft fuselages of the two-seated Nick fighter (Ki-45) and single-seater Randy night fighter (Ki-102) types. The highest monthly production of engines was 450 in November 1944 (Table A) and dropped to 410 just prior to the first U. S. air assault on this plant early in January, 1945. Fuselage production went from a high of 119 in August 1944 to a pre-attack low of 50 in December, 1944 (Table B).

a. The Akashi plant, most important of Kawasaki factories, together with other plants turned out 25 per cent of the engines used in all Japanese army combat aircraft. This was indicative of its importance as a military target.

b. Engines used in the two types of fighter fuselages produced at Akashi came from the Mitsubishi Plant in Nagoya.

c. Production for both engines and fuselages was considerably decreased during the year of 1945 as indicated in Table C. A primary function of the Akashi Plant was to test engines produced in all

Kawasaki plants, as well as to manufacture parts for engines which were assembled at Akashi and other company installations. Typical of this procedure were the 128 engines produced during the month of July 1945 of which two-thirds were air cooled and were assembled at the Kawasaki Futami Plant. The remaining one-third was liquid-cooled engines of which 60 per cent were assembled at the Takatsuki plant and 40 per cent at the Akashi Plant. All of the 128 engines were, however, tested at Akashi.

6. Air Attacks Reported by Plant Officials. The following air attacks were reported by officials of the Kawasaki Aircraft Company, Akashi Plant. (For reference to actual attacks which took place see Section V, AIR ATTACKS.)

19 January	High-explosive attack	7 July	Incendiary attack
22 June	High-explosive attack	26 July	High-explosive attack
26 June	High-explosive attack	30 July	High-explosive attack

7. Financial Loss

a. Attack on 19 January 1945

Buildings	¥ 43,268,000
Machinery, tools	9,904,000
Stock	9,847,000
Semi-finished products	62,895,000
Miscellaneous	4,148,000
	¥130,062,000

The above total was recognized and paid by the insurance company.

(The attack of 19 January 1945 was made with 500-pound bombs fused 0.10 seconds nose and 0.025 seconds tail but as this study deals with 4,000-pound bombs, this information is given only as a matter of record.)

TABLE A

ENGINE PRODUCTION - November, 1944
(All Kawasaki Plants)

TYPE	PRODUCTION	TYPE PLANE IN WHICH USED	AMERICAN CODE NAME
HA-115	~~210~~ 257	(a) Ki-48 (Light Bomber) (b) Nakajima Fighter	Lily 1 Oscar 2
HA-40	~~200~~ 172	Ki-61 (Fighter)	Tory 1
HA-140	~~70~~ 21	Ki-61 (Modified Fighter)	Tory 1
Total	~~480~~ 450		

TABLE B

FUSELAGE PRODUCTION 1944 (Both Types)
(All Kawasaki Plants)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
76	78	86	88	62	70	111	119	109	97	51	50

TABLE C

ENGINE AND FUSELAGE PRODUCTION 1945
(All Kawasaki Plants)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Engines assembled at Akashi and other Kawasaki Plants and tested at Akashi	158	69	50	292	285	195	128	None
Fuselage	14	34	24	44	18	18	14	None

8. Employees. Prior to the 19 January 1945 attack, approximately 25,000 workers were employed at the Kawasaki Akashi Plant. After that attack, a gradual dispersal of workers took place. By the time of the attack of 22 June 1945 only 15,000 workers remained.

9. Dispersal of Tools and Parts. On 1 January 1945 the number of machines (presses, machine tools, and the like) at the target was 2,171. When the 22 June 1945 strike occurred only 324 machines remained. Of these, 228 located in the engine section were classified as "mostly tools," while 96 remaining in the fuselage plant were classified as "mostly presses." Dispersal which took place between February and April 1945 consisted, in the main, of tools and parts as indicated in Table D.

TABLE D

	Dispersal of Tools (Akashi Plant) - Feb through Apr, 1945*		
MONTH	TOOLS & PARTS	MOVED TO	NUMBER MOVED
Feb to Apr	Crank shafts, rods & camshafts of liquid cooled engines	Ibaragi Plant of Osaka Seisa Co.	194
Mar	Cutters	Otsu Branch	90
Apr	Trial parts, jigs and fixtures	Nishinomiya Branch	222
Apr	Jigs and fixtures	Yashiro Branch	141

* Japanese source.

10. Unexploded Bombs. The Japanese reported that in all air attacks there was a total of 32 unexploded bombs as indicated in Table E below. Upon visual inspection of the target no unexploded bombs or low-order detonations were in evidence.

TABLE E

	Unexploded Bombs*				
ATTACK	19 Jan 45	22 Jun 45	26 Jun 45	28 Jul 45	30 Jul 45
NUMBER	30	None	None	2	None
DISPOSAL TIME	3 weeks	None	None	Not Given	None

* Japanese source.

11. Casualties from Air Attacks. Dead and injured as a result of air attacks are listed in Table F.

TABLE F

	CASUALTIES*					
Date of Attack	19 Jan 45	22 Jun 45	26 Jun 45	7 Jul 45	28 Jul 45	30 Jul 45
Dead	268	5	5	None	None	None
Injured	99	7	19	1	None	None

* Japanese source.

12. Damage to Buildings from Air Attacks. Japanese officials of the Kawasaki Co. recorded damage to buildings, possibility of repair, and repairs completed. A summary of this information follows in Table G.

TABLE G

ESTIMATED DAMAGE TO BUILDINGS			
Date of Attack	% of Damage	% of Damage Repairable	% Actually Repaired
19 Jan 45	40	30	15
22 Jun 45	15	7	None
26 Jun 45	10	5	None
28 Jul 45	Slight	2	None
30 Jul 45	Slight	1	None

V THE ATTACKS

1. The Kawasaki Akashi Plant was bombed four times as a primary target. One attack was with 500-pound bombs, the other three attacks with 4,000-pound bombs. Damage resulting from 4,000-pound bombs will be discussed under Section VI, ANALYSIS OF DAMAGE. In paragraph IV 6 is a table of Japanese origin, listing air attacks. This table may be compared with the following resume. Further detailed attack data may be found in Table I.

a. 19 January 1945. Sixty-two aircraft of the Twentieth Air Force attacked the Kawasaki Akashi Plant with 500-pound bombs. Bombing altitudes ranged from a high of 27,400 feet to a low of 25,100 feet and all aircraft bombed visually.

b. 9 June 1945. On this date 24 aircraft, each carrying three 4,000-pound bombs, attacked the Kawasaki Akashi Plant as their primary target.

(1) Eight-tenths to ten-tenths undercast obscured the target and bombing was by radar. Results were unobserved.

(2) Bombing altitudes ranged between 17,400 feet and 16,700 feet.

c. 22 June 1945. The plant was attacked by one group of the 313th Wing in a daylight effort. The target was designated as primary for visual and radar. Bombing altitude was 16,000 feet base for the lead squadron with the second and third air squadrons in trail stacked at intervals of 500 feet above the lead squadron.

(1) Twenty-five aircraft bombed the primary target. An average of 6.5 tons of 4,000-pound, light-case M56 bombs was carried by each aircraft.

(2) Due to haze encountered over the target the lead bombadiers had difficulty in identifying the aiming point and as a result the axis of attack for the formations varied.

d. 26 June 1945. The plant was again attacked by one group of the 313th Wing in a daylight strike and was designated as the primary visual and radar target.

(1) With extreme undercast weather conditions and broken clouds at the assembly point, aircraft were unable to assemble and bomb in formation. Only three aircraft succeeded in bombing in formation. All other aircraft bombed individually. Ice which formed on the bombardier's compartments and the almost solid undercast made bombing by radar necessary.

(2) Bombing altitudes varied from 15,000 to 25,000 feet. Each aircraft carried three 4,000-pound bombs.

e. 7 July 1945. Aircraft of the Twentieth Air Force bombed the Akashi urban area with incendiary bombs on this date. Many of the incendiary bombs of the M69 type fell onto the property of the Kawasaki Aircraft Company.

f. 28 and 29 July 1945. On these dates Naval carrier-based aircraft dropped a number of 500-pound bombs on the airfield of the

Kawasaki Aircraft Plant. Bombs which spilled over on the plant proper caused only slight damage.

2. On visual inspection it was found that a total of forty-six 4,000-pound bombs struck the target. Table I shows distribution of hits; Bomb Plot, Figure 5, shows location of each hit; and annex to Bomb Plot, directly following Figure 5, gives points of detonation of all 4,000-pound bombs. No unexploded bombs or low-order detonations were in evidence.

3. Table N contains Photo Intelligence estimates and field survey measurements and shows only the five buildings that were partly destroyed by 4,000-pound bombs and covered by both sources. These buildings comprised about 25 per cent of the building area.

TABLE N

COMPARISON OF DAMAGE DUE TO 4,000-LB BOMBS ESTIMATED BY PHOTOGRAPHIC INTELLIGENCE AND BY FIELD SURVEY. (ALL AREAS IN THOUSANDS OF SQ FT)

PHOTO INTELLIGENCE *				FIELD SURVEY			
JTG BLDG NO	BLDG ROOF AREA (acres)	STRUCTURAL DAMAGE (acres)	PERCENTAGE	PDD BLDG NO	BLDG ROOF AREA (acres)	STRUCTURAL DAMAGE (acres)	PER CENTAGE
66	132.3	30.2	22.8	1 & 2	113.0	46.6	41.2
67	84.0	11.6	13.8	3	86.0	15.0	17.4
68	75.6	32.2	42.6	4	62.5	39.2	62.7
38	427.0	40.0	9.4	19	412.2	22.0	5.3
86	123.5	123.5	100	22	106.0	79.8	75.3
TOTAL	842.4	237.5	28.2	TOTAL	779.2	202.6	26.0

* Based on Central Interpretation Unit XXI Bomber Command Damage Assessment Reports 104 of 28 June 1945 and 120 of 8 July 1945.

TABLE I

DATE OF ATTACK		19 JANUARY 1945	9 JUNE 1945	22 JUNE 1945	26 JUNE 1945	TOTALS FOR 4000-LB ATTACKS
Weapon	Weight	500-lb	4,000-lb	4,000-lb*	4,000-lb	
	Type	Bomb GP	Bomb LC	Bomb LC	Bomb LC	
	Model	AN-M64	M56	M56	M56	
Fuzing	Nose	0.10 sec	Inst	Inst	Inst	
	Tail	0.025 sec	ND	ND	ND	
Aircraft Bombing	Visual	62	0	25	9	34
	Radar	0	24	0	22	46
	Total	62	24	25	31	80
Number Bombs Dropped		610	72	74	92	238
Tons Released over Target		152.5	144.0	148.0	184.0	476.0
Mean Point of Impact		SE Cor Bldg 19	Approximate center of NE side of Bldg 16	SW Cor Bldg 11	Approx SW Cor Bldg 1	
Axis of Attack		291° T	102° T	36 1/2° T	35 1/2° T	
Altitude of Release	Highest	27,400	17,400	19,600	26,200	
	Lowest	25,100	16,700	18,000	16,000	
Unexploded Bombs on visual inspection		None	None	None	None	None
Low Order Detonations on visual inspection		None	None	None	None	None

Total 4,000-lb bomb hits: on Bldgs 24) in open 22) 46) Further details on Bomb Plot, Fig 5

* One aircraft carried one AN-M66 2,000-lb general-purpose bomb in addition to three 4,000-lb bombs normally carried.

34

RESTRICTED

VI ANALYSIS OF DAMAGE

1. Following is an analysis of structural damage representative of the effect of 4,000-pound bombs. FIGURE 5 ~~Table 3, [illegible] damage~~ ~~[illegible] test~~, contains location of buildings and plot of damaged areas. Superficial damage which was 100 per cent throughout this target will not be discussed in detail. No assessment of damage due to incendiary bomb attacks was made and the major damaging factor was blast unless otherwise specified.

a. Buildings 1 and 2. Building 1 was a structural-steel, one-story building, used as an assembly shop, and Building 2 was attached to it although the framing was not carried through to connect them rigidly. Bomb 22 struck Building 1 as indicated on Bomb Plot, Figure 5, and Photos 1 and 2. The effect of the bomb was to knock over two interior columns and to cut the roof steel so badly that, aided by the impetus imparted by the blast, the building began to collapse. The two nearest exterior columns were distorted by blast, and, since the steel between was severed, they fell under the weight of the collapsing steel (Photo 1). Further, the removal of the two interior columns allowed the collapse to create distortion over a widespread area. The distortion carried over into Building 2 and was localized there because the connection to Building 1 was insufficiently strong to transmit heavy loads.

b. Building 3, a structural-steel, one-story building, was damaged by the effect of a near-miss (Bomb 25) approximately 35 feet from the northwest end (Photo 3). No columns were knocked down, but

several were badly distorted, and the roof steel was severely damaged.

c. Building 4, also a structural-steel, one-story building, was struck by Bomb 29 (Photos 4 and 5 present general views of damage from this hit) which knocked down several columns. Photos 6 and 7 show the two interior columns which were displaced, and Photos 8 and 9 show exterior columns. The destruction of these columns and the immediate area of roof steel (Photos 4, 5, 7) resulted in widespread collapse and distortion. There were two near-misses (Bombs 30 and 31) approximately 50 feet distant from the southwest side of the building. It could not be determined whether any structural damage resulted from these near-misses as the positive damage caused by Bomb 29 was very heavy and extended to and covered any area that would have been affected by Bombs 30 and 31.

d. Building 8, a three-story, reinforced-concrete office building, was struck by two 4,000-pound bombs. Photo 10 presents general aspects of the building (the collapse of the perthouse and the damage at extreme right of this photo were the results of 500-pound strikes and are not covered by this report). Bomb 45 exploded in the east wing of the building (Photo 11). (Photo intelligence indicates that a 500-pound bomb struck in approximately the same place as the 4,000-pound bomb. Extent of damage attributable to the 500-pound bomb could not be determined, and is, of necessity, included in this survey.) The roof and the third-story slab were destroyed for one bay, and one third-story exterior column was completely removed by the explosion. In addition, the exterior walls of the second and third floors were

Photo 1 - Bldgs. 1 and 2, Bomb 22.

Photo 2, Bldg. 1, Bomb 22

Photo 3— Bldg. 3, Bomb 25 (CRATER IN FOREGROUND) NEAR MISS 35ft. from Bldg.

Photo 4— Bldg. 4, Bomb 29 GENERAL VIEW.

Photo 5 – Bldg 4, Bomb 29, General view.

Photo 6 – Bldg. 4, Bomb 29, Interior Column blown over.

Photo 7 - Bldg. 4, Bomb 29, Interior Column Displaced.

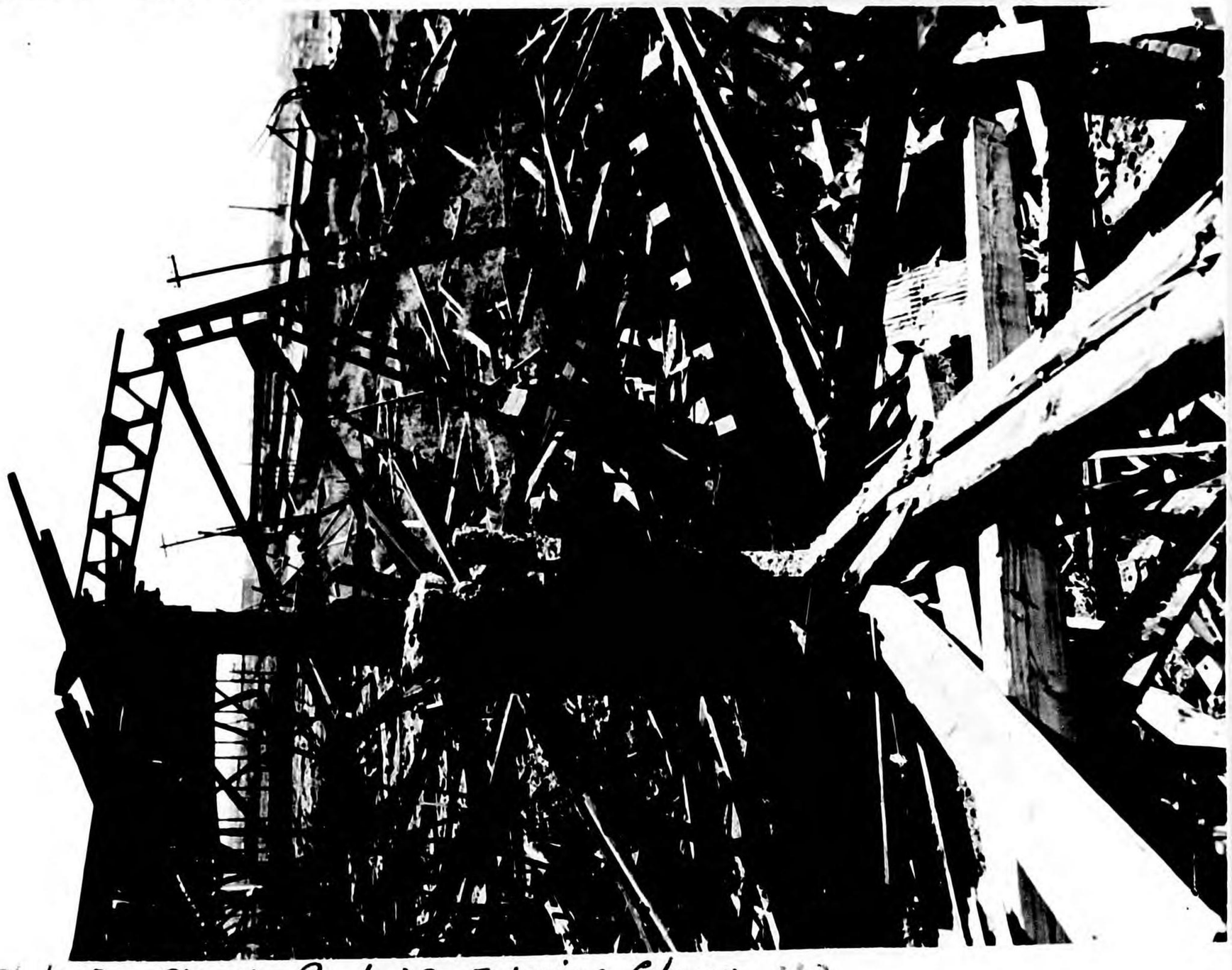


Photo 8 - Bldg. 4, Bomb 29, Exterior Column. 40

Photo 9 - Bldg. 4, Bomb #9, Exterior Columns blown over

Photo 10, Bldg. 8, Bombs 45 and 46.

blown out for two bays. The interior slabs and beams suffered in the areas indicated as damaged in Figure 1. One of the more severely damaged columns is shown in Photo 12. Bomb 46 exploded in the extreme north corner of the building as shown in Photo 10. The third-story exterior walls and the included column were blown down and outward for two bays on the northwest face (Photo 12), and one bay on the northeast face. The roof collapsed, leaving the corner column standing (Photo 12). The interior structure was damaged as shown on Figure 1. Bomb 44 was a near-miss which detonated approximately 50 feet southeast of the building and damaged first-story exterior walls and second-floor exterior beams of the adjacent five bays.

e. Building 12, a two-story, reinforced-concrete office building, was hit with two 4,000-pound bombs, 14 and 15. Bomb 15 exploded at the southeast end and Bomb 14 exploded at approximately the northwest end. Collapse was noted within three bays of each bomb. Examination of the portion still standing indicated that all of the beams, except those in one bay at the northwest end, had been damaged at the haunches as a result of shock. The building was 95 per cent structurally damaged.

f. Building 23, a one-story, structural-steel building, was also damaged by the blast from Bomb 15 which struck in Building 12. The damage extended for two bays from the eastern edge of the building (Photo 13). The blast had the effect of buckling the bottom chord members of the truss and bending the exterior columns inward. Photo 14 shows the damage caused by Bomb 15 and Photo 15 the damage caused by

Bomb 14.

g. Building 16 was a one-story, structural-steel building with saw-tooth roof. Photo 16 shows the damage caused by one bomb bursting in the roof. This damage was confined to a small area as the bomb burst about 15 feet from the east side of the building and 30 feet from the north end, causing a large portion of the blast to be expended outside of the structure. This area had previously suffered damage from a 500-pound hit, but the area damaged by the 4,000-pound bomb was much larger than, and included, the area damaged by the former.

h. Building 19, a one-story, structural-steel building with saw-tooth roof, was hit and damaged by one 4,000-pound bomb. Damage Assessment Plot, Figure 5, shows area damaged by Bomb 2.

(1) This building had been hit previously in the 500-pound-bomb attack, but no bombs fell within the damage area of the 4,000-pound bomb being discussed.

(2) Bomb 2 hit in the roof steel approximately ten feet inside the west wall. There was no crater in the concrete floor and very few fragmentation marks were observed.

(3) The column in the foreground of Photo 17 was, from all indications, directly in line with the blast, and the built-up flange which faced the explosion received the greatest part of the blast. Before the column was knocked over, the force of the explosion was transmitted through the bottom chord of the adjacent

Photo 11, Bldg. 8, Bomb 45.

Photo 12 - Bldg. 8, 3rd floor slab and column. 44

Photo 13. Showing damage to Bldg 23 and Bldg 12 by Bomb 15.

Photo 14, Bldg. 12, Bomb 15.

45

Photo 15, Bldg. 12, Bomb 14.

Photo 16 - Bldg. 16, Bomb 9.

saw-tooth truss to the next column. The process of transmitting the load through the botton chord which acted as a strut continued for five bays, in each case buckling the botton chord of the truss and putting the column out of line at the truss connection. The sixth and seventh bays in the same line were slightly distorted but not enough to justify classification as structural damage. Damage extended over an approximately circular area having a radius of four bays from the point of detonation. The structure would have to be replaced for at least 2 1/2 bays in radial distance from the bomb. The rest of the area could have been repaired without replacing a large percentage of the steel.

(4) Blast was the only cause of damage to this building. Photo 18 taken about 100 feet from the west side of the building gives a general view of the damage.

1. Building 22, a one-story, structural-steel building with saw-tooth roof, approximately 320 feet long and 280 feet wide, was used as a flight preparation shop. The trusses running perpendicular to the saw-tooth trusses and supporting them had a span of 140 feet. The height of the botton chord above the floor level was 32 feet. This structure received one hit, and several near-misses. Bomb 3 burst near one of the interior columns supporting the long-span trusses. The blast from the bomb collapsed the column (Photo 19) which pulled down

Photo 17 — Bldg. 19, Bomb 2, Point of Detonation in Right foreground.

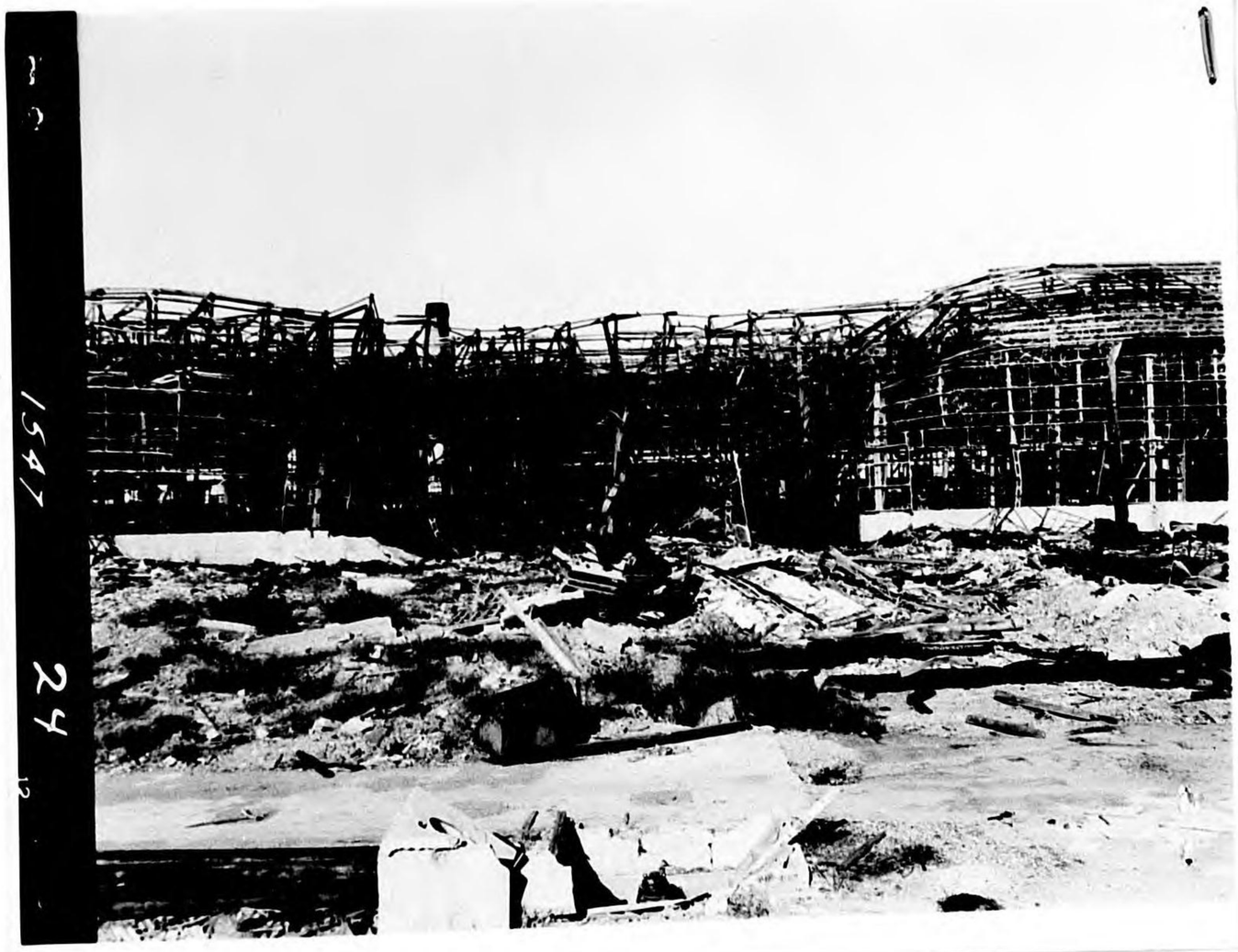


Photo 18 - Bldg 19, Bomb 2.

Photo 19 - Bldg. 22, Bomb 3, Column in left foreground caused initial collapse.

Photo 20 - Bldg. 22, Bomb 3, column with ARROW caused initial collapse.

Photo 21 – Bldg 22, Bomb 3, General view of Collapse,

Photo 22 - Side view of Bldg 22, Bomb 3.

the heavy trusses it was supporting. The trusses, which had been tied into the rest of the structure by the saw-tooth trusses, in turn pulled down and distorted trusses and framework for three more bays on one side of the hit, and two on the other side. Photos 20 and 21 show this collapse. Figure 2 indicates the position of Bomb 3 in relation to surrounding framing. Photo 19 shows the column which had collapsed in its final position. Photo 22 taken from outside the western end of the building shows how five of the exterior columns were pulled over by the collapse of the interior column. A bomb ~~which was estimated to be a 1,000-pound, general-purpose,~~ cratered 30 feet south of this structure, knocked down the hanger doors, and wracked the southern part of this building. The widespread damage in this building as the result of the collapse of one column was due to the doubling of the span of the truss, together with the higher dead load inherent in the design of long spans.

j. Building 27 was a one-story, steel building used as a plating shop. It was divided in two by an eight-inch reinforced-concrete wall running parallel to the roof trusses and as high as the bottom chord of the truss. Bomb 12 cratered 30 feet south of the south side of the building. Photo 23 indicates the effect of the blast from this bomb which pushed the south side of the building in and caused the roof to collapse. No damage occurred on the far side of the concrete wall which acted as a blast wall.

k. Building 132 was a structural-steel boiler house. Photo 24 presents general aspects and over-all damage. The one bomb affecting this structure blew over the boiler (Photo 25) and cut the corner

column, blowing the end of the building inward (Photos 26, 27, and 24). Photo 28 shows the construction and how the failure took place in the side of the building away from the stack. The reinforced-concrete stack was damaged, the concrete being knocked out over an area approximately 15 feet high by 4 feet wide (Photos 26 and 27). The foundation of the stack was apparently undisturbed and the stack appeared to be in plumb.

TARGET NO. 1547 — NAME OF PLANT

TABLE J

KAWASAKI AIRCRAFT COMPANY , AKASHI, JAPAN

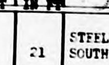
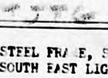
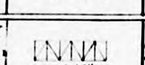
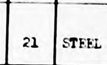
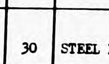
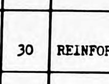
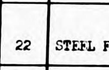
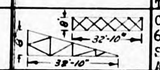
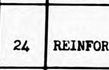
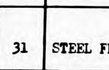
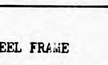
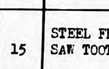
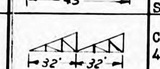
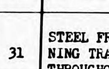
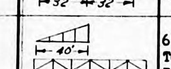
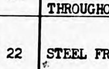
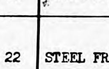
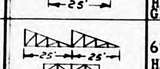
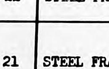
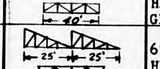
NO OF BLDG	NAME OF BUILDING	GROUND AREA OF BUILDING IN SQ FT	NO STORIES	FLR AREA IF MORE THAN ONE STORY IN SQ FT	HT OF EAVES IN FT	DESCRIPTION OF STRUCTURE	VULNERABILITY: FIRE RESISTIVE	VULNERABILITY: NON COMBUSTIBLE	VULNERABILITY: COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C C	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE – SPAN	EXTERIOR WALLS BEARING, CURTAIN – THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	STRUCTURAL DAMAGE TO BLDG SQ FT FLOOR AREA	REMARKS
1 4 2	HEAT TREAT SHOP	113,000	1		21	STEEL FRAME, SAW TOOTH ROOF - SOUTH EAST LIGHT		X		REINF CONC				CURTAIN-6" REINF CONC. TO 5'-WOOD TO EAVES ON STEEL GIRTS	CURTAIN - STEEL SASH & GLASS - CORRUGATED 1 RON	CORR. CEMENT ASBESTOS ON WOOD PURLINS IN DAMAGED PORTION OF BLDG.	46,600	SUPERFICIAL DAMAGE 100%
																		
3	ACCESSORY SHOP	86,000	1		21	STEEL FRAME, SAW TOOTH ROOF		X		REINF CONC	SAME AS BUILDING 1 AND 2	SAME AS BUILDING 1 AND 2		CURTAIN-REINFORCED CONCRETE TO 5' WOOD TO EAVES ON STEEL GIRTS	NONE	CORR. CEMENT ASBESTOS ON WOOD PURLINS	15,000	SUPERFICIAL DAMAGE 100%
4	BUILDING UNDER CONSTRUCTION	62,500	1		21	STEEL FRAME		X		REINF CONC				CURTAIN-CONCRETE WALL TO 2' 6"-WOOD SHEATHING ABOVE	NONE	CORR. CEMENT ASBESTOS ON WOOD PURLINS	39,200	SUPERFICIAL DAMAGE 100%
																		
132	BOILER HOUSE	6,500	1		30	STEEL FRAME		X		REINF CONC		NONE		CURTAIN WALL CORR. IRON OVER STEEL GIRTS	NONE	CORR. CEMENT ASBESTOS OVER WOOD PURLINS AND WOOD SHEATHING	3,600	SUPERFICIAL DAMAGE 100%
												NONE						
8	OFFICE	16,800	3	50,400	30	REINFORCED CONCRETE	X			8"CONC REIN AT 12"CNTRS WITH ½"		SAME AS EXT. COL.	NONE	12" CURTAIN WALL REINF. CONCRETE FIRST STORY. 10" REINF. CONCRETE FOR TWO TOP STORIES	8" REINFORCED CONCRETE CURTAIN	REINF. CONCRETE ROOF, ASPHALT FELT ROOFING COVERED WITH TILE	15,900	ROOF AREA STRUCTURALLY DAMAGED - 9,600 SQ FT SUPERFICIAL DAMAGE 100%
11	TRIAL SHOP	70,000	1		22	STEEL FRAME		X		8" REINF CONC		SAME AS EXT. COL.		CONCRETE CURTAIN WALL 6" THICK 4' HIGH STEEL SASH AND GLASS TO ROOF AND EAVES	NONE	WOOD SHEATHING ON WOOD PURLINS AND ROOFING FELT	7,900	SUPERFICIAL DAMAGE 100%
12	MATERIAL INSPECTION DEPARTMENT	10,800	2	21,600	24	REINFORCED CONCRETE	X			CONC,1ST FL. 8" 2ND FL. 6" THICK		SAME AS EXT. COL.	NONE	12" REINFORCED CONCRETE CURTAIN WALL	8" CONCRETE REINFORCED CURTAIN WALL	REINF. CONCRETE ROOF, ASPHALT FELT ROOFING COVERED WITH TILE	20,520	ROOF AREA STRUCTURALLY DAMAGED - 10,260 SQ FT SUPERFICIAL DAMAGE 100%
16	ASSEMBLY BUILDING	380,000	1		31	STEEL FRAME		X		6" REINF CONC				CURTAIN WALL REINFORCED CONCRETE TO 4', STEEL SASH AND GLASS TO EAVES	NONE	WOOD SHEATHING ON WOOD PURLINS AND ROOFING FELT	12,100	SUPERFICIAL DAMAGE 100%
19	ENGINE PARTS	411,700	1		15	STEEL FRAME, SAW TOOTH ROOF - SAW TOOTH RUNS TRANSVERSE		X		CONC		SAME AS EXT. COL.		CURTAIN-6" CONCRETE TO 4' STEEL SASH TO EAVES AND GLASS	NONE	CORRUGATED CEMENT ASBESTOS ROOFING ON WOOD PURLINS	22,000	SUPERFICIAL DAMAGE 100%
22	FLIGHT PREP. SHOP	106,000	1		31	STEEL FRAME, SAW TOOTH TRUSS RUNNING TRANSVERSE GLASS - STEEL SASH THROUGHOUT		X		CONC		SAME AS EXT. COL.		6" CONCRETE CURTAIN WALL TO SILL STEEL SASH TO EAVES	BAMBOO BLAST WALL FILLED WITH SAND	CORRUGATED ASBESTOS ON WOOD PURLINS	79,800	SUPERFICIAL DAMAGE 100%
23	RESEARCH BUILDING	40,800	1		22	STEEL FRAME		X		CONC		SAME AS EXT. COL.		6" CONCRETE WALLS 4'0" HIGH STEEL SASH AND GLASS TO EAVES	6" REINFORCED CONCRETE	STEEL TRUSS WOOD PURLINS WOOD SHEATHING ASPHALT FELT	5,200	SUPERFICIAL DAMAGE 100%
26	HEAT TREATMENT	63,000	1		22	STEEL FRAME		X		CONC		SAME AS EXT. COL.		6" CONCRETE WALLS 4'0" HIGH, STEEL SASH AND GLASS ABOVE TO THE EAVES	NONE	CORRUGATED IRON ON STEEL PURLINS	34,800	SUPERFICIAL DAMAGE 100%
27	HEAT TREATING SHOP	17,500	1		21	STEEL FRAME		X		CONC		SAME AS EXT. COL.		6" CONCRETE WALLS 4'0" HIGH, STEEL SASH AND GLASS ABOVE TO THE EAVES	8" THICK CONCRETE WALL 22'0" HIGH DIVIDING BUILDING IN HALF	CORRUGATED IRON ON STEEL PURLINS	8,500	SUPERFICIAL DAMAGE 100%
58	OIL STORAGE SHOP	6,000	1		10	SMALL CONCRETE BUILDING WITH STEEL ROOF	X			CONC	NONE	NONE		8" REINFORCED CONCRETE BEARING WALL	NONE	STEEL PURLINS CORR. CEMENT ASBESTOS	6,000	SUPERFICIAL DAMAGE 100%

TABLE J

TARGET NO. 1547 NAME OF PLANT KAWASAKI AIRCRAFT COMPANY, AKASHI, JAPAN

NO OF BLDG	NAME OF BLDG	GROUND AREA OF BUILDING	NO. STORIES	FLR AREA IF MORE THAN ONE STORY	HT OF EAVES	DESCRIPTION OF STRUCTURE	VULNERABILITY: FIRE RESISTIVE	VULNERABILITY: NON COMBUSTIBLE	VULNERABILITY: COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C.C.	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE - SPAN	EXTERIOR WALLS BEARING, CURTAIN - THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	STRUCTURAL DAMAGE TO BLDG SQ FT FLOOR AREA	REMARKS
106	UNKNOWN	2,400	NO INFORMATION, BLDGS. DESTROYED BY FIRE.			WOODEN STRUCTURE			X		NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	2,400	NONE
107	UNKNOWN	2,400	"	"	"	WOODEN STRUCTURE			X								2,400	
108	UNKNOWN	3,100	"	"	"	WOODEN STRUCTURE			X								3,100	
116	PURCHASE INSP. SHOPS	5,100	"	"	"	WOODEN STRUCTURE			X								5,100	
117	PURCHASE INSP. SHOPS	4,400	"	"	"	WOODEN STRUCTURE			X								4,400	
118	PURCHASE INSP. SHOPS	4,400	"	"	"	WOODEN STRUCTURE			X								4,400	
119	PURCHASE INSP. SHOPS	4,400	"	"	"	WOODEN STRUCTURE			X								4,400	
122	PATTERN SHOP	10,800	"	"	"	WOODEN STRUCTURE			X								6,500	
123	MATERIAL TESTING SHOP	2,200	"	"	"	WOODEN STRUCTURE			X								2,200	
124	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
125	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
126	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
127	MATERIAL TESTING SHOP	900	"	"	"	WOODEN STRUCTURE			X								900	
128	REPAIR SHOP	17,500	"	"	"	WOODEN STRUCTURE			X								17,500	
129	CASTING SHOP	23,500	"	"	"	WOODEN STRUCTURE			X								23,500	
133	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	
134	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	
135	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	
136	DINING ROOM	6,500	"	"	"	WOODEN STRUCTURE			X								6,500	

TABLE J

TARGET NO. 1547 NAME OF PLANT KAWASAKI AIRCRAFT COMPANY, AKASHI, JAPAN

NO OF BLDG	NAME OF BLDG	GROUND AREA OF BUILDING IN SQ FT	NO. STORIES	FLR. AREA IF MORE THAN ONE STORY IN SQ FT	HT. OF EAVES IN FT	DESCRIPTION OF STRUCTURE	VULNERABILITY: FIRE RESISTIVE	VULNERABILITY: NON COMBUSTIBLE	VULNERABILITY: COMBUSTIBLE	FLOORS TYPE & THICKNESS	EXTERIOR COLUMNS & DIMENSIONS C.C.	INTERIOR COLUMNS & DIMENSIONS	TRUSSES TYPE - SPAN	EXTERIOR WALLS BEARING, CURTAIN - THICKNESS	INTERIOR WALLS BEARING, CURTAIN THICKNESS	ROOF	STRUCTURAL DAMAGE TO BLDG SQ FT FLOOR AREA	REMARKS
68	UNKNOWN	3,000	NO INFORMATION, BLDGS DESTROYED BY FIRE			WOODEN STRUCTURE			X		NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	NO INFORMATION, BUILDINGS DESTROYED BY FIRE	3,000	
69	TRANSFORMER HOUSE	1,000	"	"	"	WOODEN STRUCTURE			X								1,000	
70	UNKNOWN	2,400	"	"	"	WOODEN STRUCTURE			X								2,400	
71	UNKNOWN	1,800	"	"	"	WOODEN STRUCTURE			X								1,800	
121	WOODWORKING SHOP	28,200	"	"	"	WOODEN STRUCTURE			X								28,200	
130	JIG ASSEMBLY SHOP	8,100	"	"	"	WOODEN STRUCTURE			X								8,100	
131	JIG ASSEMBLY SHOP	3,500	"	"	"	WOODEN STRUCTURE			X								3,500	
137	DINING ROOM	1,500	"	"	"	WOODEN STRUCTURE			X								1,500	
138	DINING ROOM	1,500	"	"	"	WOODEN STRUCTURE			X								1,500	
140	DORMITORY	38,800	"	"	"	WOODEN STRUCTURE			X								29,900	

Photo 23 - Bldg. 27, Bomb 12, DAMAGE CAUSED by NEAR MISS.

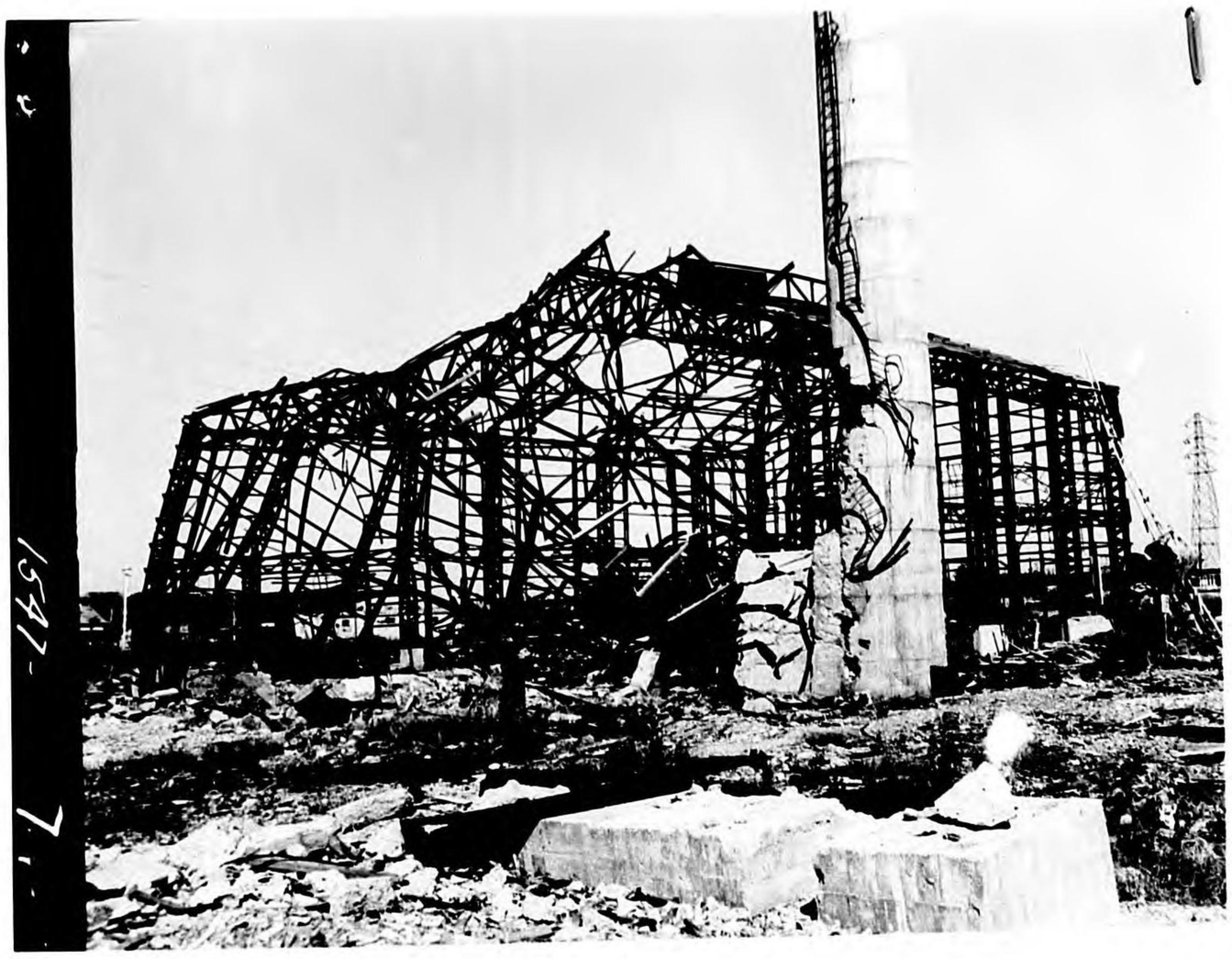


Photo 24 - Bldg 13r, Bomb 23, GENERAL VIEW.

Photo 25, Bldg 132, Bomb 23, Boiler blown over.

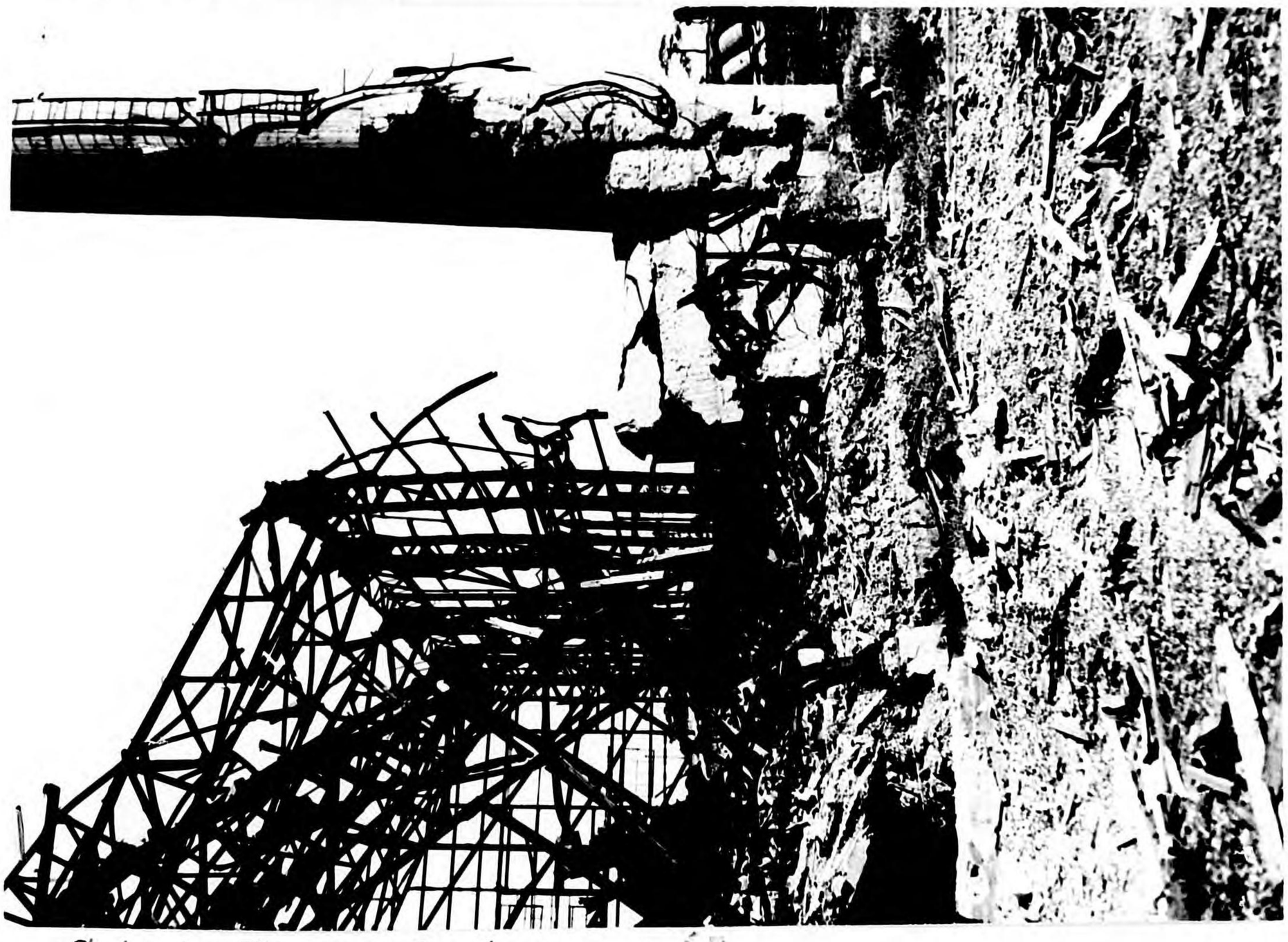


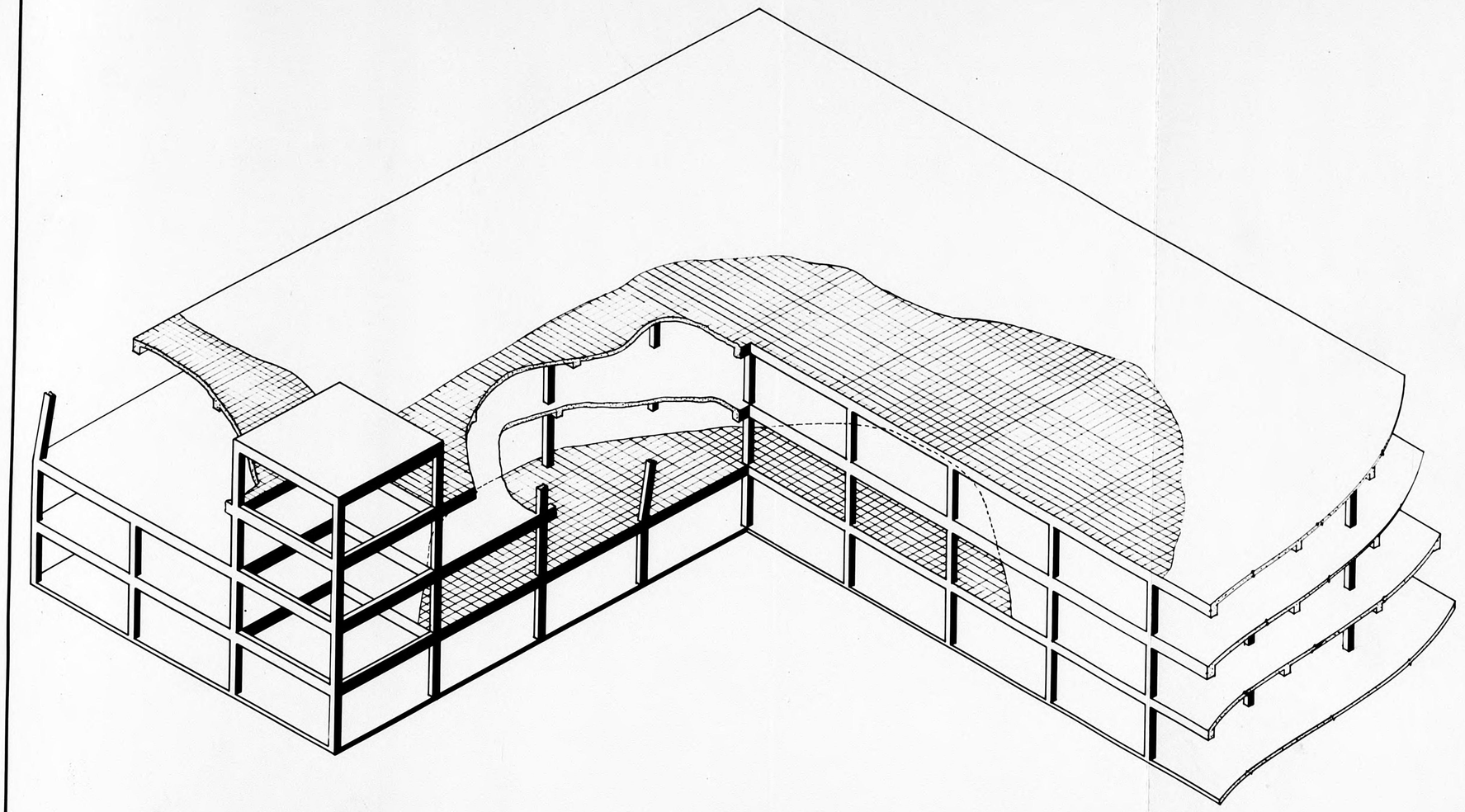
Photo 26, Bldg. 132, Bomb 23.

Photo 27, Bldg 132, Bomb 23, damaged Stack and Columns.

Photo 28, Bldg. 132, Bomb 23, boiler blown over.

58

Photo 29- Overall view of fire damage caused by several 4,000-lb bombs.



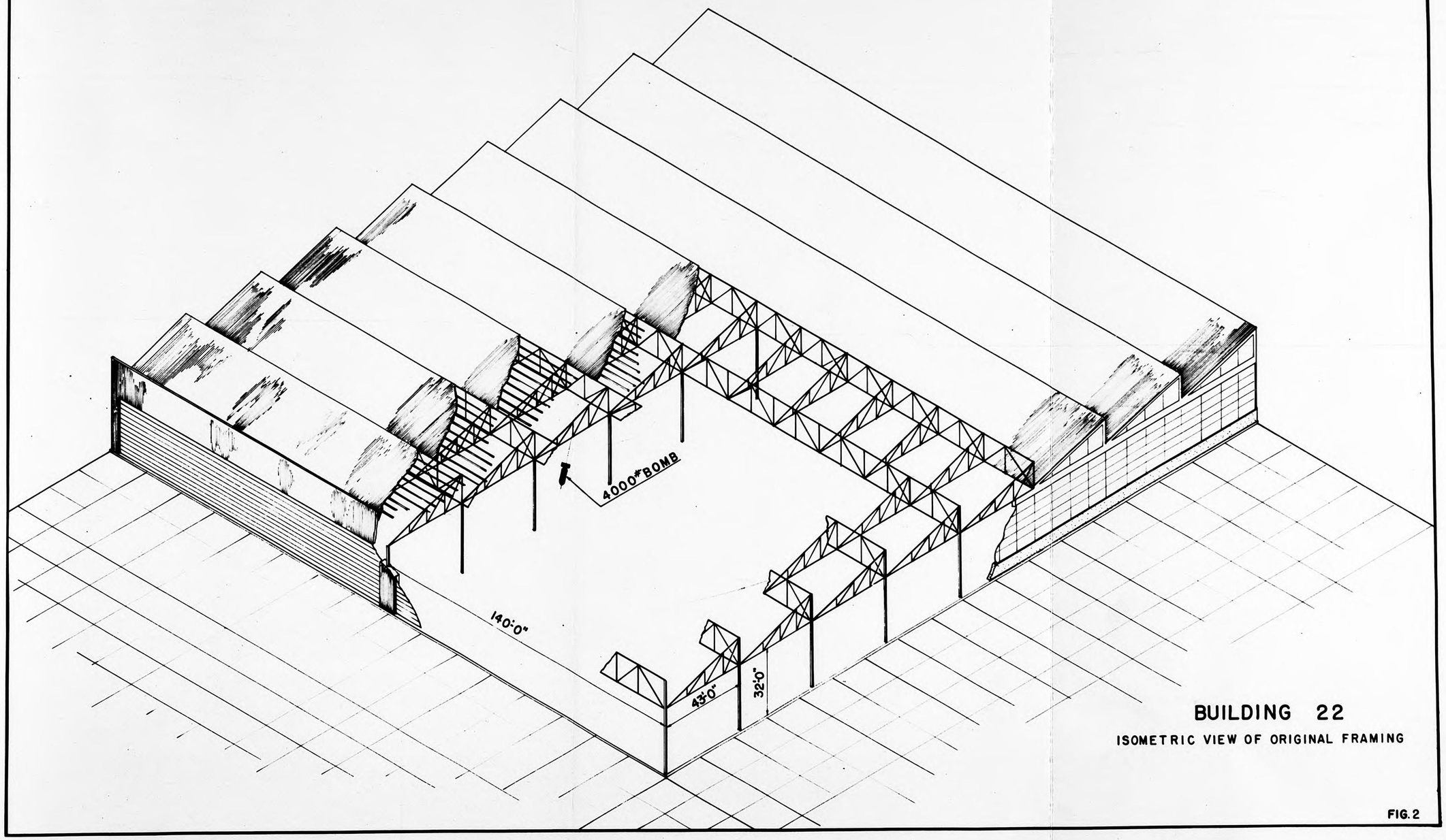
STRUCTURALLY DAMAGED AREAS
NOTE COLLAPSED PORTIONS REMOVED
ON THIS DRAWING
DAMAGED AREA ON 2ND FLOOR CONTINUES
AS OUTLINED BY DOTTED LINE

BUILDING #8

DAMAGED AREAS-4000 LB BOMBS

notes corrected on original

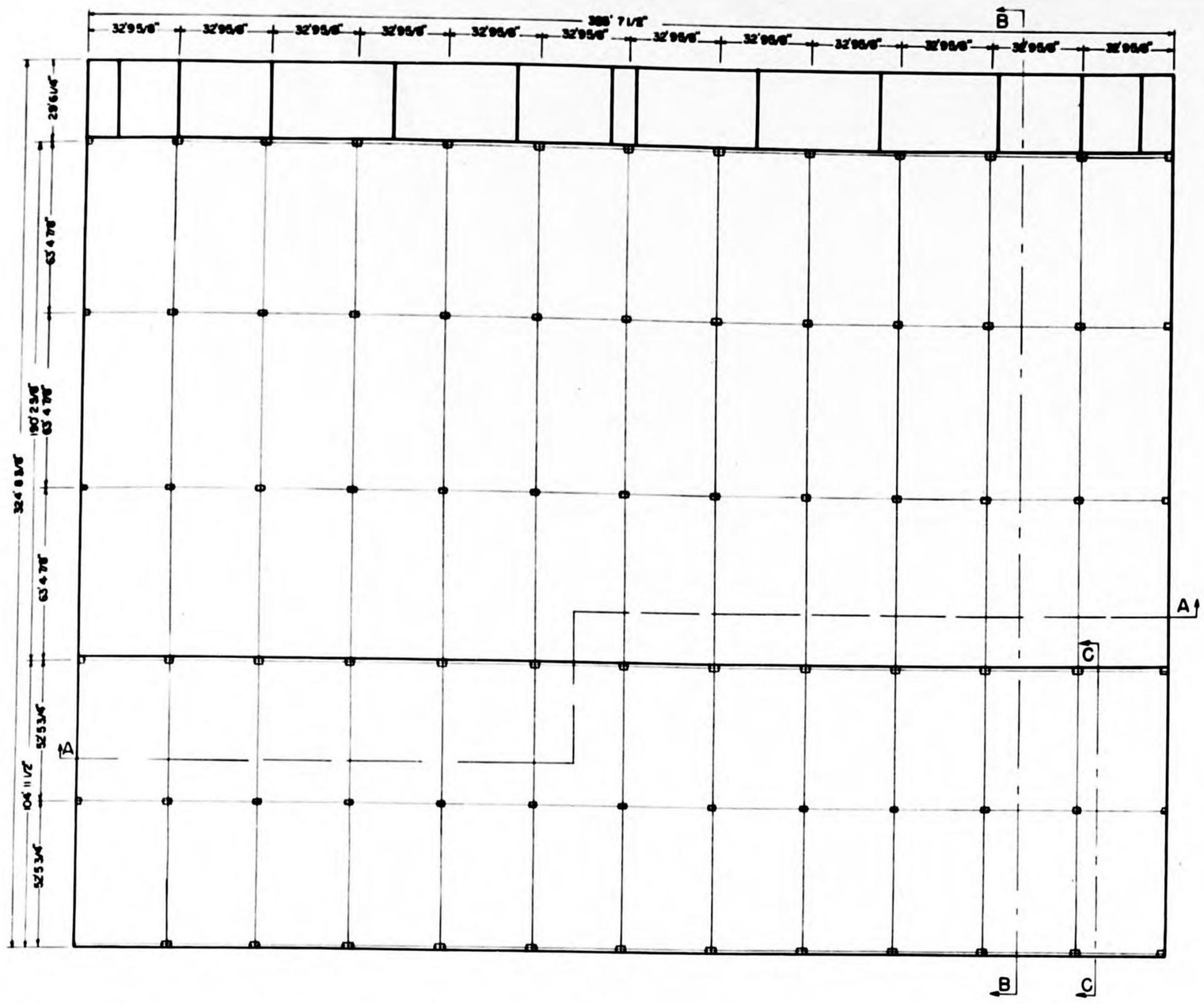
FIG. 1



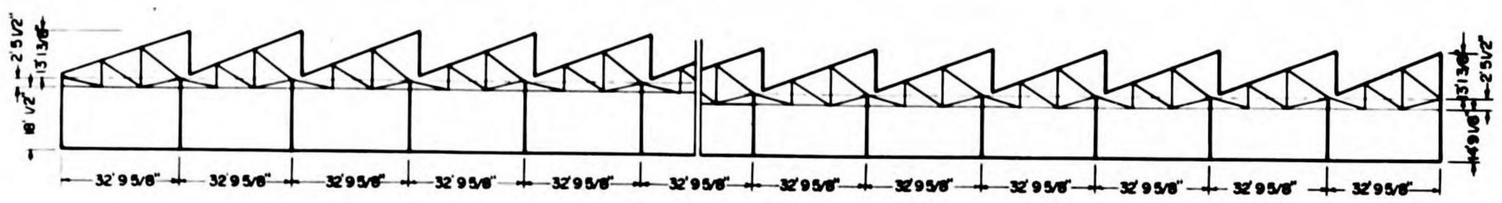
BUILDING 22

ISOMETRIC VIEW OF ORIGINAL FRAMING

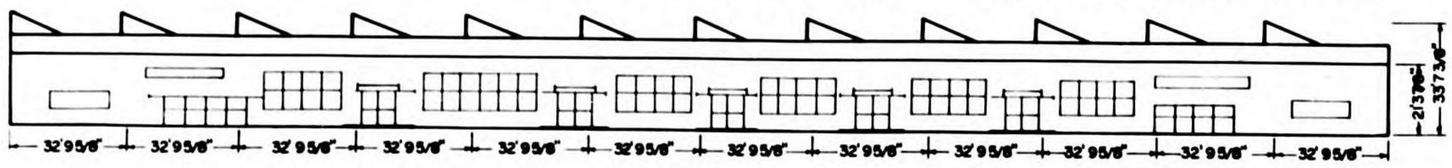
FIG. 2



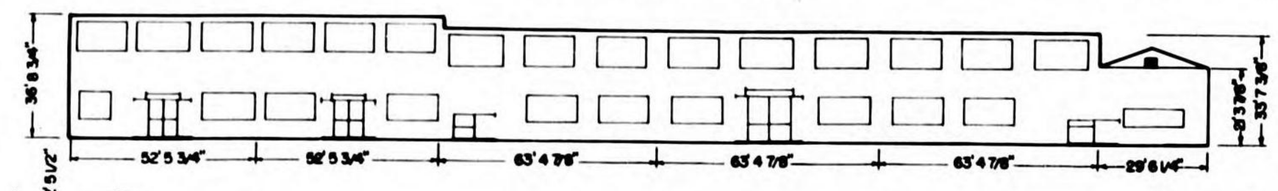
SECTION A-A



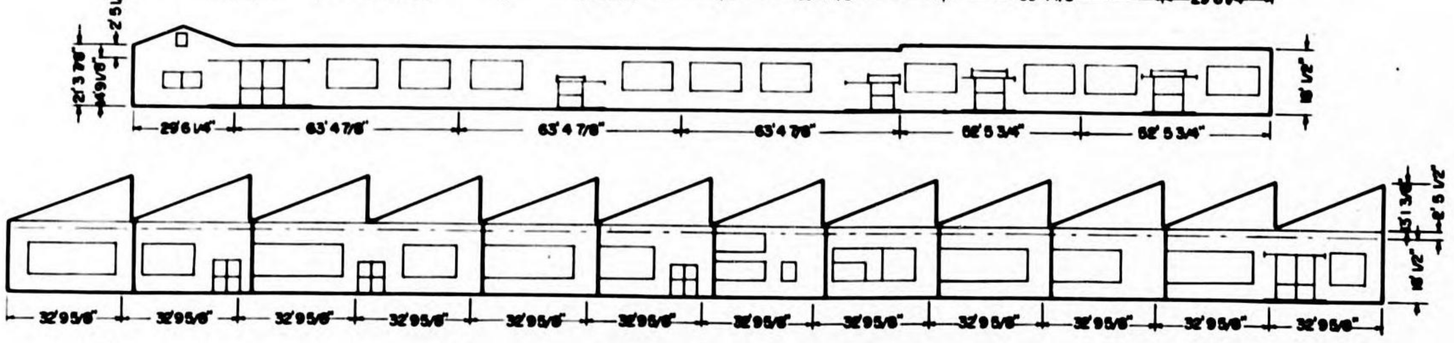
ELEVATION N-E SIDE



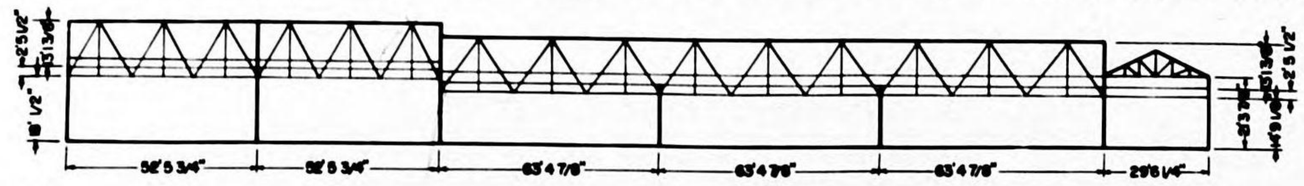
ELEVATION S-E SIDE



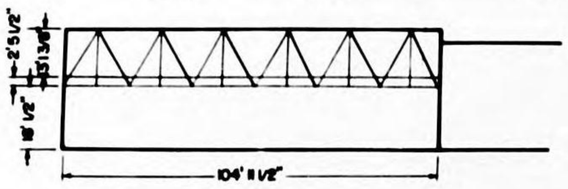
ELEVATION N-W SIDE



SECTION B-B



SECTION C-C

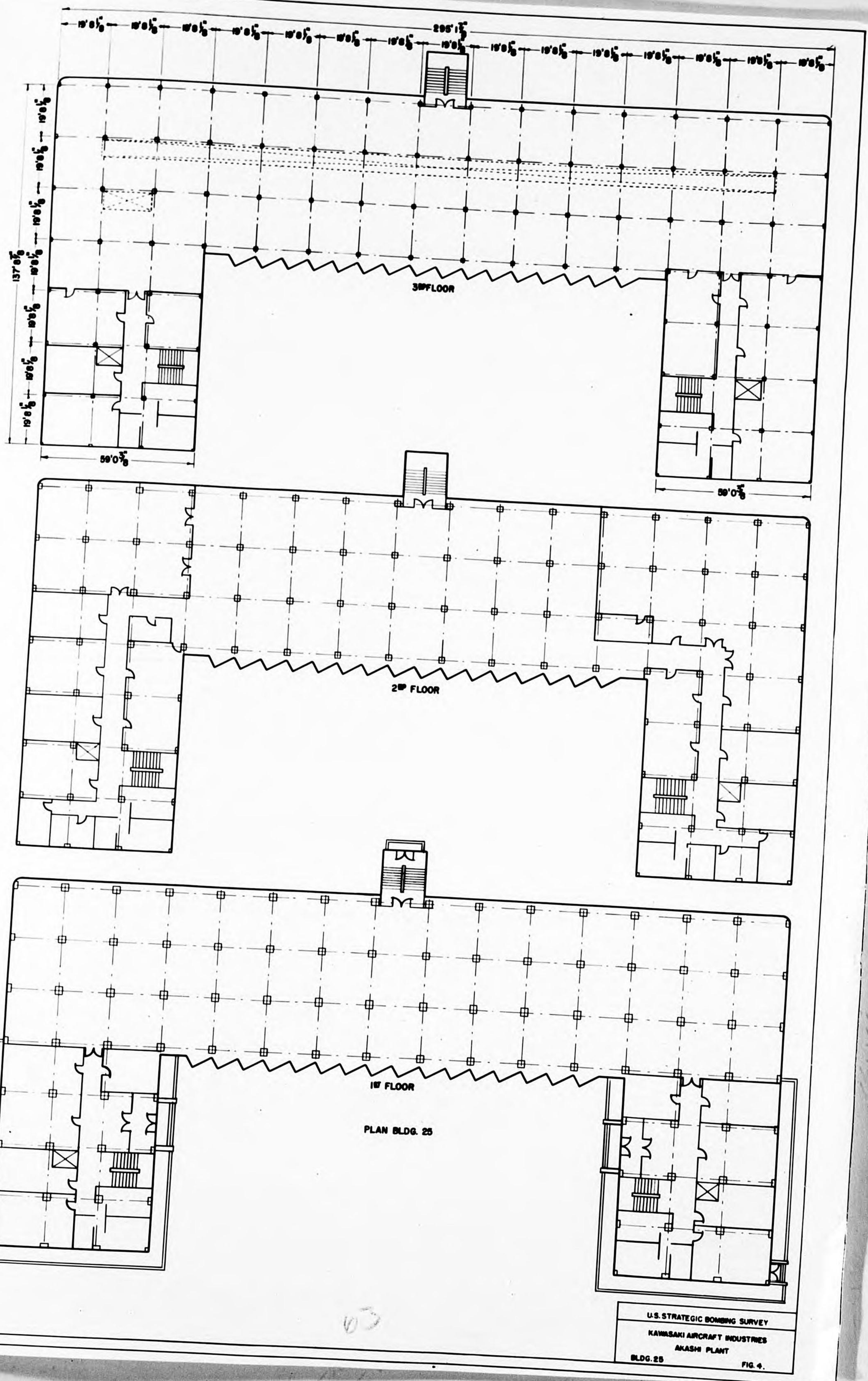


PLAN, ELEVATIONS, & SECTIONS,
OF BLDGS. 1 & 2

US STRATEGIC BOMBING SURVEY

KAWASAKI AIRCRAFT INDUSTRIES
AKASHI PLANT
BLDGS. NO. 1 & 2 FIG. 3.

62



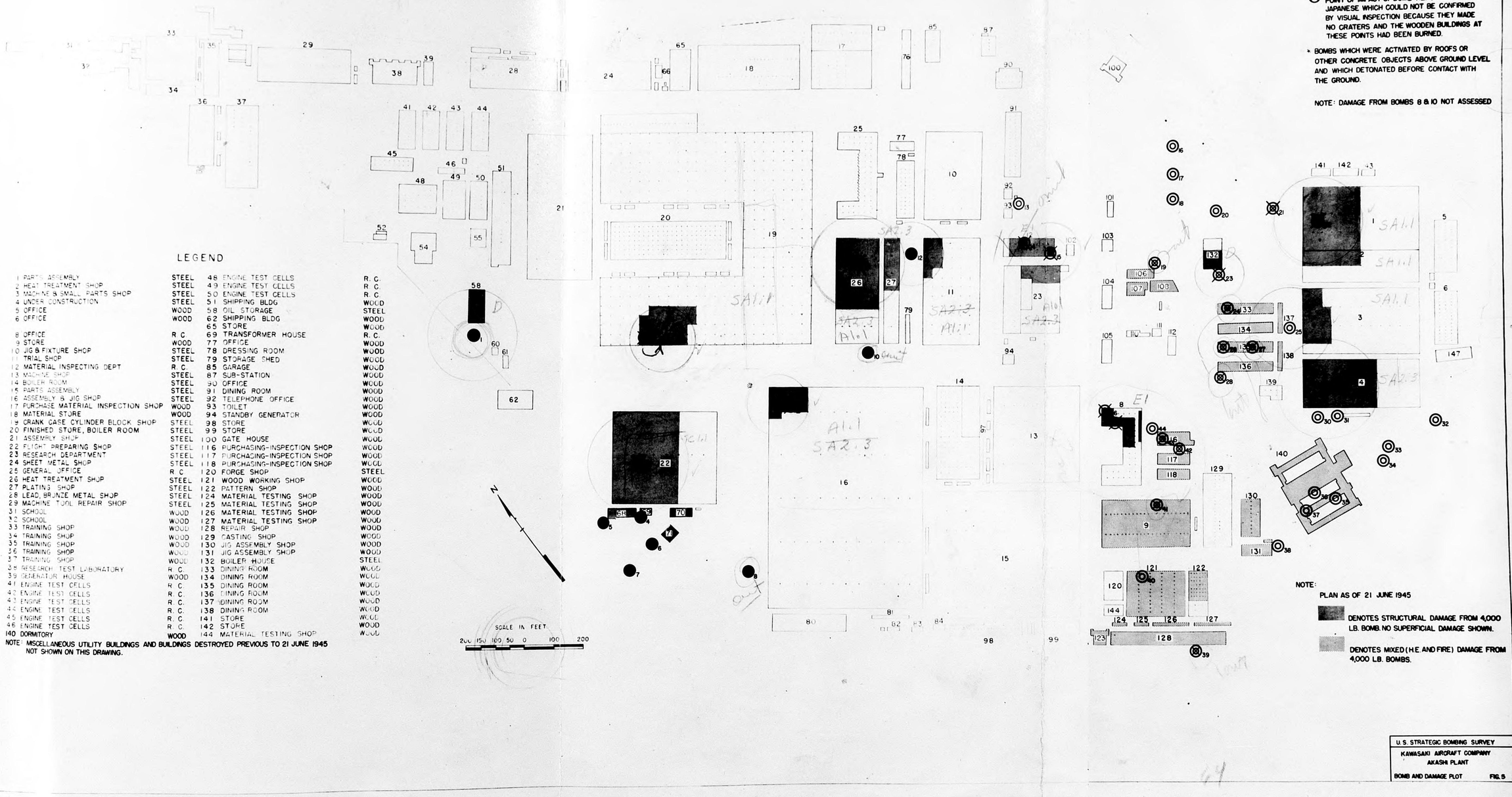
PLAN BLDG. 25

U.S. STRATEGIC BOMBING SURVEY

KAWASAKI AIRCRAFT INDUSTRIES

AKASHI PLANT

BLDG. 25 FIG. 4.


AIRBURST *
CRATER
ATTACK OF 26 JUNE 1945
AIRBURST
CRATER
ATTACK OF 22 JUNE 1945
POINT OF IMPACT OF BOMB REPORTED BY JAPANESE WHICH COULD NOT BE CONFIRMED BY VISUAL INSPECTION BECAUSE THEY MADE NO CRATERS AND THE WOODEN BUILDINGS AT THESE POINTS HAD BEEN BURNED.
* BOMBS WHICH WERE ACTIVATED BY ROOFS OR OTHER CONCRETE OBJECTS ABOVE GROUND LEVEL AND WHICH DETONATED BEFORE CONTACT WITH THE GROUND.
NOTE: DAMAGE FROM BOMBS 8 & 10 NOT ASSESSED
LEGEND
1 PARTS ASSEMBLY
2 HEAT TREATMENT SHOP
3 MACHINE & SMALL PARTS SHOP
4 UNDER CONSTRUCTION
5 OFFICE
6 OFFICE
8 OFFICE
9 STORE
10 JIG & FIXTURE SHOP
11 TRIAL SHOP
12 MATERIAL INSPECTING DEPT
13 MACHINE SHOP
14 BOILER ROOM
15 PARTS ASSEMBLY
16 ASSEMBLY & JIG SHOP
17 PURCHASE MATERIAL INSPECTION SHOP
18 MATERIAL STORE
19 CRANK CASE CYLINDER BLOCK SHOP
20 FINISHED STORE, BOILER ROOM
21 ASSEMBLY SHOP
22 FLIGHT PREPARING SHOP
23 RESEARCH DEPARTMENT
24 SHEET METAL SHOP
25 GENERAL OFFICE
26 HEAT TREATMENT SHOP
27 PLATING SHOP
28 LEAD, BRONZE METAL SHOP
29 MACHINE TOOL REPAIR SHOP
31 SCHOOL
32 SCHOOL
33 TRAINING SHOP
34 TRAINING SHOP
35 TRAINING SHOP
36 TRAINING SHOP
37 TRAINING SHOP
38 RESEARCH TEST LABORATORY
39 GENERATOR HOUSE
41 ENGINE TEST CELLS
42 ENGINE TEST CELLS
43 ENGINE TEST CELLS
44 ENGINE TEST CELLS
45 ENGINE TEST CELLS
46 ENGINE TEST CELLS
140 DORMITORY
STEEL 48 ENGINE TEST CELLS
STEEL 49 ENGINE TEST CELLS
STEEL 50 ENGINE TEST CELLS
STEEL 51 SHIPPING BLDG
WOOD 58 OIL STORAGE
WOOD 62 SHIPPING BLDG
65 STORE
R.C. 69 TRANSFORMER HOUSE
WOOD 77 OFFICE
STEEL 78 DRESSING ROOM
STEEL 79 STORAGE SHED
R.C. 85 GARAGE
STEEL 87 SUB-STATION
STEEL 90 OFFICE
STEEL 91 DINING ROOM
STEEL 92 TELEPHONE OFFICE
WOOD 93 TOILET
WOOD 94 STANDBY GENERATOR
STEEL 98 STORE
STEEL 99 STORE
STEEL 100 GATE HOUSE
STEEL 116 PURCHASING-INSPECTION SHOP
STEEL 117 PURCHASING-INSPECTION SHOP
STEEL 118 PURCHASING-INSPECTION SHOP
R.C. 120 FORGE SHOP
STEEL 121 WOOD WORKING SHOP
STEEL 122 PATTERN SHOP
STEEL 124 MATERIAL TESTING SHOP
STEEL 125 MATERIAL TESTING SHOP
WOOD 126 MATERIAL TESTING SHOP
WOOD 127 MATERIAL TESTING SHOP
WOOD 128 REPAIR SHOP
WOOD 129 CASTING SHOP
WOOD 130 JIG ASSEMBLY SHOP
WOOD 131 JIG ASSEMBLY SHOP
WOOD 132 BOILER HOUSE
WOOD 133 DINING ROOM
WOOD 134 DINING ROOM
R.C. 135 DINING ROOM
R.C. 136 DINING ROOM
R.C. 137 DINING ROOM
R.C. 138 DINING ROOM
R.C. 141 STORE
R.C. 142 STORE
WOOD 144 MATERIAL TESTING SHOP
NOTE: MISCELLANEOUS UTILITY BUILDINGS AND BUILDINGS DESTROYED PREVIOUS TO 21 JUNE 1945 NOT SHOWN ON THIS DRAWING.
SCALE IN FEET
200 150 100 50 0 100 200
NOTE:
PLAN AS OF 21 JUNE 1945
DENOTES STRUCTURAL DAMAGE FROM 4,000 LB. BOMB. NO SUPERFICIAL DAMAGE SHOWN.
DENOTES MIXED (H.E. AND FIRE) DAMAGE FROM 4,000 LB. BOMBS.
U.S. STRATEGIC BOMBING SURVEY
KAWASAKI AIRCRAFT COMPANY
AKASHI PLANT
BOMB AND DAMAGE PLOT
FIG. 5

ANNEX TO BOMB PLOT FIGURE 5

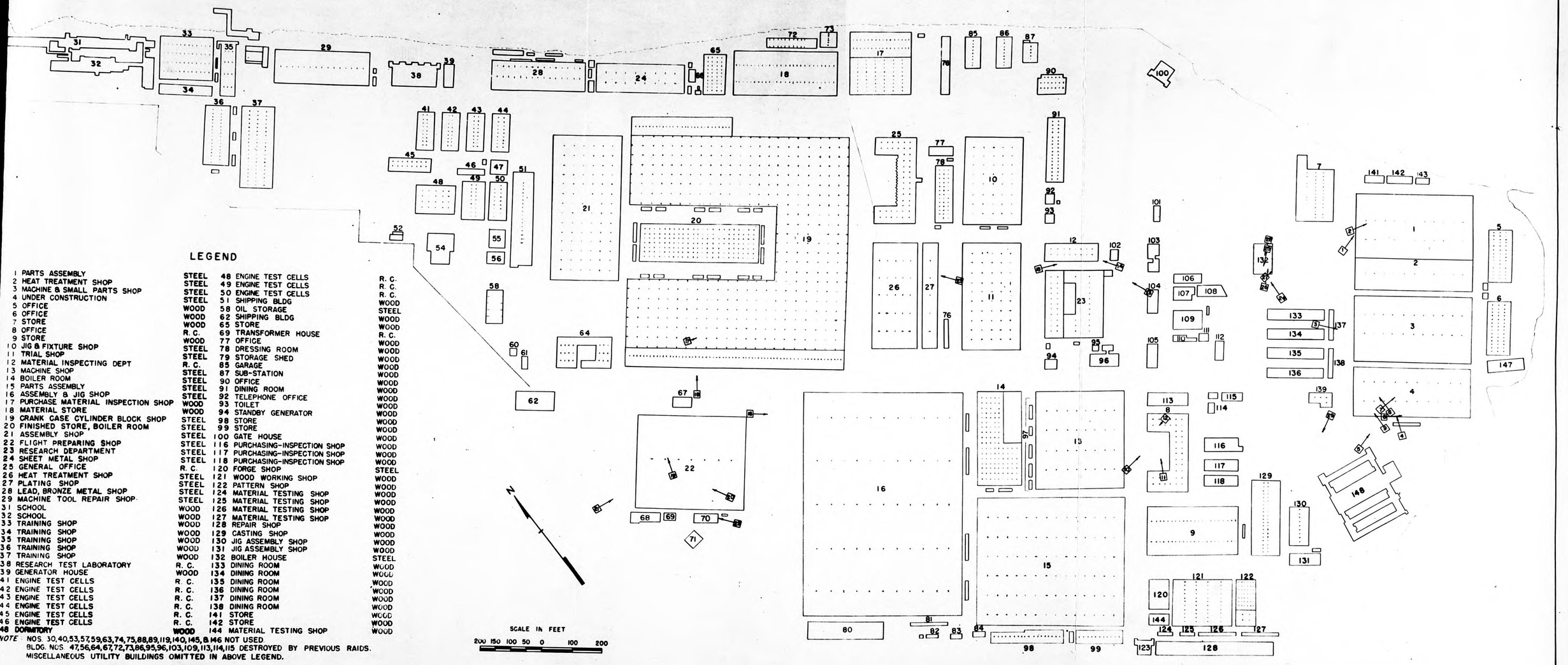
Following is a brief resume of the points of impact of all the 4,000-pound light-case M56 bombs which struck the Akashi plant of the Kawasaki Aircraft Company. It should be kept in mind that these bombs were all fuzed instantaneous nose and non-delay tail.

Bomb Number	Description
1	Deep and wide crater with slow fuse action in soft soil.
2	Air burst* with detonation at main truss level.
3	Air burst with super-quick fuze action at roof surface level.
4	Slight crater. Bomb burst probably occurred four to six feet above ground level.
5	Shallow and wide crater with immediate fuse action on contact with ground.
6	Shallow crater with fuze action on contact with rubble pile approximately two feet high.
7	Deep and wide crater with slow fuse action in soft soil.
8	Deep crater with much of the blast deflected upward.
9	Air burst just above building eaves.
10	Small cone-shaped crater with little deflection of the blast.
11	Air burst high and above eaves.
12	Wide, shallow crater with little deflected blast.
13	Wide, shallow crater.
14	Air burst above roof initiated on contact.
15	Ditto

Bomb Number	Description
16	Crater 6 feet to 8 feet deep with steep sloping sides.
17	Ditto
18	Ditto
19	This bomb was plotted by Japanese but, at time of survey, ground evidence neither confirmed or denied its location or its detonation.
20	Deep, wide crater.
21	Air burst point of detonation not determined.
22	Air burst well below the eaves.
23	Air burst below eaves and outside of building.
24	This bomb was plotted by Japanese but, at time of survey, ground evidence neither confirmed or denied its location or its detonation.
25	Small crater with steep sides.
26	This bomb was plotted by Japanese but, at time of survey, ground evidence neither confirmed or denied its location or its detonation.
27	Ditto
28	Ditto
29	Air burst at or just below eaves.
30	Small crater with steep sides. No more than 15 feet in diameter, no lip.
31	Ditto

Bomb Number	Description
32	Wide crater in side of embankment with blast deflected upward.
33	Wide, shallow crater with thin scattered lip.
34	Ditto
35	Crater size undetermined.
36	Ditto
37	Ditto
38	Wide, shallow crater.
39	This bomb was plotted by Japanese but, at time of survey, ground evidence neither confirmed or denied its location or its detonation.
40	Small crater with steep sides.
41	This bomb was plotted by Japanese but, at time of survey, ground evidence neither confirmed or denied its location or its detonation.
42	Ditto
43	Ditto
44	Shallow crater with instantaneous fuze on contact of bomb with ground.
45	Air burst above roof on contact.
46	Ditto

* Reference to airburst bombs throughout, means bombs which were activated and detonated by some solid object prior to contact with the ground.



LEGEND

1	PARTS ASSEMBLY	STEEL	48	ENGINE TEST CELLS
2	HEAT TREATMENT SHOP	STEEL	49	ENGINE TEST CELLS
3	MACHINE & SMALL PARTS SHOP	STEEL	50	ENGINE TEST CELLS
4	UNDER CONSTRUCTION	STEEL	51	SHIPPING BLDG
5	OFFICE	WOOD	58	OIL STORAGE
6	OFFICE	WOOD	62	SHIPPING BLDG
7	STORE	WOOD	65	STORE
8	OFFICE	R. C.	69	TRANSFORMER HOUSE
9	STORE	WOOD	77	OFFICE
10	JIG & FIXTURE SHOP	STEEL	78	DRESSING ROOM
11	TRIAL SHOP	STEEL	79	STORAGE SHED
12	MATERIAL INSPECTING DEPT	R. C.	85	GARAGE
13	MACHINE SHOP	STEEL	87	SUB-STATION
14	BOILER ROOM	STEEL	90	OFFICE
15	PARTS ASSEMBLY	STEEL	91	DINING ROOM
16	ASSEMBLY & JIG SHOP	STEEL	92	TELEPHONE OFFICE
17	PURCHASE MATERIAL INSPECTION SHOP	WOOD	93	TOILET
18	MATERIAL STORE	WOOD	94	STANDBY GENERATOR
19	CRANK CASE CYLINDER BLOCK SHOP	STEEL	98	STORE
20	FINISHED STORE, BOILER ROOM	STEEL	99	STORE
21	ASSEMBLY SHOP	STEEL	100	GATE HOUSE
22	FLIGHT PREPARING SHOP	STEEL	116	PURCHASING-INSPECTION SHOP
23	RESEARCH DEPARTMENT	STEEL	117	PURCHASING-INSPECTION SHOP
24	SHEET METAL SHOP	STEEL	118	PURCHASING-INSPECTION SHOP
25	GENERAL OFFICE	R. C.	120	FORGE SHOP
26	HEAT TREATMENT SHOP	STEEL	121	WOOD WORKING SHOP
27	PLATING SHOP	STEEL	122	PATTERN SHOP
28	LEAD, BRONZE METAL SHOP	STEEL	124	MATERIAL TESTING SHOP
29	MACHINE TOOL REPAIR SHOP	STEEL	125	MATERIAL TESTING SHOP
31	SCHOOL	WOOD	126	MATERIAL TESTING SHOP
32	SCHOOL	WOOD	127	MATERIAL TESTING SHOP
33	TRAINING SHOP	WOOD	128	REPAIR SHOP
34	TRAINING SHOP	WOOD	129	CASTING SHOP
35	TRAINING SHOP	WOOD	130	JIG ASSEMBLY SHOP
36	TRAINING SHOP	WOOD	131	JIG ASSEMBLY SHOP
37	TRAINING SHOP	WOOD	132	BOILER HOUSE
38	RESEARCH TEST LABORATORY	R. C.	133	DINING ROOM
39	GENERATOR HOUSE	WOOD	134	DINING ROOM
41	ENGINE TEST CELLS	R. C.	135	DINING ROOM
42	ENGINE TEST CELLS	R. C.	136	DINING ROOM
43	ENGINE TEST CELLS	R. C.	137	DINING ROOM
44	ENGINE TEST CELLS	R. C.	138	DINING ROOM
45	ENGINE TEST CELLS	R. C.	141	STORE
46	ENGINE TEST CELLS	R. C.	142	STORE
148	DORMITORY	WOOD	144	MATERIAL TESTING SHOP

NOTE: NOS. 30,40,53,57,59,63,74,75,88,89,113,140,145,&146 NOT USED
BLDG. NOS. 47,56,64,67,72,73,86,95,96,103,109,113,114,115 DESTROYED BY PREVIOUS RAIDS.
MISCELLANEOUS UTILITY BUILDINGS OMITTED IN ABOVE LEGEND.

U.S. STRATEGIC BOMBING SURVEY
KAWASAKI AIRCRAFT INDUSTRIES
AKASHI PLANT
GEN. LAYOUT & PHOTO PLOT FIG. 6

PDD REPORT 72
PART 2

UNITED STATES STRATEGIC BOMBING SURVEY

(PACIFIC)

PHYSICAL DAMAGE DIVISION

REPORT 72

SECTION IV

PART 2

Effects of 4,000-pound Bombs Dropped on the Plant of the Sumitomo Light Metals Industry, Limited, Osaka, Japan

Target 90.25 - 263A

Dates of Survey: 24 October - 16 November 1945

PDD REPORT 72
PART 2

CONTENTS

AA+P

I OBJECT OF STUDY

The object of this study was to determine the amount of physical damage done to the Sumitomo Light Metals Industry plant at Osaka by 4,000-pound light-case M56 high-explosive bombs.

II SUMMARY

1. The Sumitomo Osaka plant, located in the outskirts of the city of Osaka, was roughly trapezoidal in shape and covered 91.5 acres. The plant, as a whole, was divided into two sections, namely, the light metals industry and the propeller plant; aluminum and copper alloys were produced in the former, and finished propellers in the latter. Each of these divisions employed its own individual manager, although both were part of the Sumitomo Osaka Plant. Buildings of both divisions were principally one-story wood- or steel-frame structures. The steel-frame structures had moderate spans and large-capacity cranes. In comparison with other targets studied by this team, this target had a high ratio (redacted) of buildings, 45.4 acres, to the total area (91.5 acres).

2. The plant was bombed, as a primary target, by Twentieth Air Force B-29 aircraft on 26 June 1945 and 24 July 1945. Both attacks were made with 4,000-pound light-case M56 bombs. The attack of 26 June 1945 was made with the aid of radar and resulted in only slight damage to the target. The attack of 24 July 1945, however, was made visually and caused considerable damage. In both attacks a total of 870 tons of high-explosive bombs were released over the target and visual inspection showed that 104 bombs struck the plant proper. Of these 104 bombs, 85 exploded in or on buildings, and 19 exploded in the open. There was

no evidence of unexploded bombs or low-order detonations.

3. Field survey determined that of a total of 1,978,700 square feet of original roof area, 1,416,075 square feet [redacted] structurally damaged by 4,000-pound high-explosive bombs. In comparison, Photo Intelligence estimated that of a total of 2,119,400 square feet of roof area, 705,800 square feet [redacted] structurally damaged.

III GENERAL INFORMATION

1. The study of the Osaka plant of the Sumitomo Light Metals Industry, Ltd., was made during the period 24 October - 16 November 1945. This study was made by Field Team 3 which made the report contained in Part I hereof.

2. [redacted]

Major H. W. McCord	Team Chief
Major W. N. Dillin	Ordnance Officer
Major R. B. Wilson	Structural Engineer
Captain P. Elliott	Structural Engineer
Lieut J. E. Bennett, USNR	Structural Engineer
Lieut P. Casamajor, USNR	Photo Interpreter
Lieut (jg) W. H. Gorham, USNR	Machine Tool Assessment
1st Lt F. A. Bellucci	Ordnance Officer
Mr. C. K. Parker	Interpreter
Sgt M. Calvin	Photographer
Bosn 1/c J. B. Daniels, USNR	Draftsman
Y 3/c H. Albrecht, USNR	Clerk
S 2/c C. L. Hirrel, Jr, USNR	Draftsman

3. All data contained in this report were gathered from Twentieth Air Force operational reports, plant records, personal interview, and visual observation.

4. Several drafts of bomb plots were supplied by plant officials, but due to errors in these drafts it was necessary for the ordnance members of the team to prepare new plots.

5. The target area at the time of the survey was in a condition of ruin as a result of U. S. air attacks. Minor salvage activities were in progress, but presented no problems and did not obscure any pertinent facts.

IV [redacted] THE TARGET

1. Official Personnel. Mr. H. Kasuga was president of the Sumitomo Light Metals Industry, Ltd., and Dr. Tomojiro Tanabe was managing director of the copper works (Target 263A) at Osaka. General information concerning plant functions, employees, attack damage, and other topics of interest were supplied by Dr. Tanabe.

2. Location. The Osaka plant of the Sumitomo Light Metals Industry, Ltd., was located near the water front on reclaimed land between the Shin Yodo and Aji rivers. The installation consisted of two parts; one, the light-metals industry, and the second, the propeller plant. Though both parts were units of the Sumitomo Light Metals Industry, Ltd., at the same location, each was managed separately.

a. Information obtained from the operators of Sumitomo Light Metal Industry indicates that at the time the plant was built doubt existed as to the stability of the soil conditions, and, for this

reason, exceedingly heavy building foundations were used. As time passed, settlement did occur, amounting to more than an inch per year. The area in which the plant was located was subject to extreme fluctuations in water level, so that under the worst conditions the entire area was inundated. The Sumitomo plant was surrounded by heavy sea walls, and a canal running through the center of the plant was buried. Seepage of water into the plant area was rather high, and a pumping station was installed to keep the water level down by pumping water from furnace flues and machinery pits. As the soil conditions became progressively worse, additional pumps were placed in service to keep ahead of the seeping water. During the 4,000-pound bomb attacks, large cracks developed in the sea walls and the pumping station was totally damaged. The plant area was at once almost entirely covered with three to four inches of water. As a result, production was impeded and all equipment and materials suffered damage.

3. Building Data. The light-metals plant of the Sumitomo Light Metals Plant was approximately square, with a total built-up area of 35.6 acres. Generally speaking, the principal buildings were one-story, steel-frame structures having moderate spans and fairly large-capacity cranes. Minor buildings were of wood construction. The propeller manufacturing portion of the plant adjoined the other and was triangular in shape; the majority of the buildings were wooden and covered 9.8 acres. When viewed together, the propeller plant and the light-metals works were trapezoidal in shape. The propeller plant was at the south end of the plot; building numbers in the propeller plant are

followed by the letter "p" on FIGURES 9 and 10.

4. Capital. As of 1 June 1945 the Sumitomo Light Metals Industry, Ltd., had a paid up capital of 415,000 yen ($103,750 at the prewar rate of exchange). The Sumitomo holding company (Sumitomo Housha) held 24 per cent of the stock.

a. Value of the Osaka plant was reported by the Japanese to be:

Buildings	¥ 85,734,610
Machinery	48,824,718
Materials and finished and partially finished products	90,821,700
	¥225,381,028

5. Products. The light-metals works produced aluminum alloys (rolled, forged, extruded, etc.) and copper alloy. The monthly production of aluminum alloys was 1,800 tons, and that of copper alloy, 1,200 tons. The propeller plant, using the alloys, turned out finished propellers. The raw materials and finished propellers were sent to various aircraft factories throughout the country.

6. Air Attacks Reported by Japanese. Plant officials reported that three air attacks were carried out against this target on the dates given below. They also indicated the number and type of bombs which struck the plant area.

Date	Bomb Type	Bomb Hits
1 June 1945	Incendiary	158
	Small high explosive	120

Date	Bomb Type	Bomb Hits
26 June 1945	High-explosive	3
24 July 1945	High-explosive	116

Detailed information on air attacks will be found under Section V, THE [redacted] ATTACKS."

7. Employees. This plant employed 11,000 workers. Average attendance in 1945 prior to air attacks was 85 per cent. This relatively high percentage dropped to between 40 and 50 per cent for a period of ten days after the attack of 26 June 1945. [redacted] the 24 July 1945 attack the number of workers dropped to only 20 per cent of the original total, and at the time of the survey only a few small salvage crews were working.

8. Dispersal of Machines and Equipment. The main machines, including 251 furnaces and 70 machine tools, totaling 1,978, were moved to the near-by Nauiwa Higher School. About one-half of the research instruments and equipment [redacted] moved to the Tsujiku building in Osaka. All of these tools and instruments remained undamaged, as neither of these places of safety was hit in any air attacks.

9. Financial Loss. The high-explosive-bomb attack of 24 July 1945 was, according to the Japanese, so effective that the entire plant was demolished to a point where only scrap remained.

a. This scrap value was itemized as follows:

Buildings	¥ 102,321
Machinery	73,507
Materials, Products, etc.	5,657,579
	¥5,833,407

b. According to the Japanese, the total damage resulting from all attacks, in percentage of destruction, was as follows:

Buildings	92.9%
Machines	89.1%
Materials and Products	93.4%

c. It was estimated by the Japanese that it would have taken one year to repair a maximum of 15 per cent of the damaged machinery due to the lack of proper electrical equipment.

10. Casualties. The following table, supplied by the Japanese, shows the number of dead and wounded resulting from each of the three air attacks on this target.

TABLE A

DATE	KILLED	INJURED
1 June 1945	3	0
26 June 1945	0	0
24 July 1945	250	100

V THE [redacted] ATTACKS

1. The Sumitomo Osaka plant was attacked with high-explosive bombs by aircraft of the Twentieth Air Force on 26 June 1945 and 24 July 1945. In both of these attacks the target was primary for visual and radar. The weapon employed was the 4,000-pound light-case M56 high-explosive bomb. (Detailed information on these high-explosive attacks will be found in Table C.) The Japanese reported attacks on 1 June 1945, 26 June 1945, and 24 July 1945. A brief resumé of each attack which

affected the plant follows. In addition, Bomb Plot, Figure 10, shows the location of each high-explosive bomb hit, and the annex to the Bomb Plot shows the point of detonation of each bomb hit.

a. 1 June 1945. A force of 458 B-29 aircraft of the Twentieth Air Force dropped 2,788.5 tons of incendiary and fragmentation bombs on the industrial urban area of Osaka of which Target 263A was a part. Some of these bombs, though not specifically aimed at Target 263A, spilled over into the plant area and the Japanese therefore recorded an attack, which they added, did no appreciable damage to the plant proper. The fragmentation bombs were dropped to prevent efficient fire fighting by the Japanese, and it is assumed that the "small bombs" referred to by plant officials were these 20-pound fragmentation bombs.

b. 26 June 1945. The Sumitomo Osaka plant was attacked by two groups of the 58th Wing, Twentieth Air Force. It was designated as the primary visual and radar target, with one assigned mean point of impact (MPI).

(1) Ten-tenths undercast at the assembly point prevented aircraft from forming and bombing visually. Bombing was accomplished by single aircraft utilizing radar.

(2) Bombing altitudes varied between 19,000 feet and 23,000 feet. Sixty-four aircraft, carrying an average of 13,000 pounds of 4,000-pound light-case bombs, released their loads over the target.

c. 24 July 1945. The primary target was attacked by two groups of the 58th Wing, Twentieth Air Force, with 4,000-pound light-case

M56 bombs. Visibility was excellent and all formations made visual runs.

(1) Bombing altitudes were 19,900 feet base for the lead squadron in each group, the second and third air squadrons being stacked at intervals of 500 feet above the lead squadron.

(2) The greatest difficulty encountered was from smoke in the target area which partially obscured the aiming point. Reference and offset aiming points were used, and bombing was accomplished as planned.

2. On visual inspection it was found that a total of 104 4,000-pound bombs struck the target. Table C shows the distribution of hits in buildings and in the open, and the Bomb Plot, Figure 10, shows the location of each hit. No evidence of unexploded bombs or low-order detonations was found.

3. The following table contains Photo Intelligence and Field Survey measurements of damage done by 4,000-pound bombs in the two attacks on this plant.

TABLE B

	Original roof area (sq ft)	Roof area structurally damaged (sq ft)	Roof area structurally damaged
Photo Intelligence*	2,119,400	705,800	33
Field Survey	1,978,000	1,416,100	71

* Based on Central Interpretation Unit, Twentieth Air Force, Damage Assessment Report No. 160, Dated 2 August 1945.

TABLE C

Date of Attack		26 June 1945	24 July 1945	Totals
Weapon	Weight in lbs Type Model	4,000 Light-case M56	4,000 Light-case M56	
Fuzing	Nose Tail	Inst Non-delay	Inst Non-delay	
Aircraft Bombing	Visual Radar Total	1 63 64	82 0 82	83 63 146
Number Bombs Dropped		191	244	435
Tons Released Over Target		382	488	870
Mean Point of Impact Planned		SW corner of Bldg 12	Center of E Side of Bldg 58	
Axis of Attack		35° T	35° T	
Altitude of Release	Highest (feet)	23,000	22,100	
	Lowest (feet)	19,000	19,900	

Total 4,000-pound Hits: In Bldgs 85; In Open 19; Total 104

Further details on Bomb Plot, Figure 10.

VI ANALYSIS OF DAMAGE

1. The damage assessment contained in this report is shown on the Damage Plot, Figure 10, and in Table D, and was made on the basis of structural and superficial damage. So that this section may be clearly understood, definitions of structural and superficial damage follow:

a. Structural damage. Structures or parts of structures rendered inadequate, unsafe, or unusable for the purpose for which they were designed.

b. Superficial damage. Destruction of curtain walls, roofs

~~and other non-structural parts of buildings.~~

2. The total roof area at this plant prior to air attacks comprised 1,978,700 square feet. The two 4,000-pound-bomb attacks on this target resulted in the structural damage of 1,416,075 square feet. Primary and secondary fires caused 348,300 square feet of the roof-area damage and obliterated all evidence of blast and fragmentation damage. Though the origin and spread of fires were not determined, burned buildings were assessed as structurally damaged if they appeared on photos taken prior to the high-explosive attacks. All damage assessed resulted from either blast or fire unless otherwise specified.

3. Damage Plot, Figure 10, shows the roof areas structurally and superficially damaged by 4,000-pound bombs, as well as locations of buildings in the target. Bombs referred to by number following text may be located on the Bomb Plot, Figure 10.

4. Following are descriptions of incidents in this target which were subjected to analytical observation. In a considerable number of cases, the buildings were so severely damaged that the exact details of the effect of the individual bombs could not be determined. Effort was made to describe several typical incidents in each type of construction.

a. Building 3 was a one-story, steel-frame structure used as a shop for the manufacturing of tubing. Bomb 42 struck in the building near the western side. One exterior column was torn out and other columns were severely distorted. Photo 1 shows the nature of damage in this building.

b. Building 9 was a steel-frame warehouse with a heavy crane runway, used for loading purposes, which extended over the river bank. Bomb 46 struck this building near the river edge, demolishing a considerable area of the framing. Since the crane was on the overhanging portion of the structure, this part collapsed into the water. The rest of the building, extending back approximately 360 feet from the shore line, was severely distorted throughout. Photo 2 shows the state of collapse.

c. Building 11, a steel-frame mill building, used as a forging shop, received one hit (Bomb 47) in the north end. No columns were knocked out, and the damage was confined to the northern half of the building.

d. Building 13 was a one-story, steel-frame machine shop. Bomb 37 struck this building, demolishing steel for six bays. The entire building was collapsed or severely distorted. Photos 3 and 4 show the destruction in this building.

e. Building 14, a heat-treating shop, was a one-story, steel-frame mill building. In plan this building was L-shaped, one wing running west, the other south, from the reentrant angle. Two bombs struck the building. Bomb 44 exploded on contact with the ground, cutting several columns and causing collapse or distortion of the entire west wing. Bomb 43 struck in the reentrant angle. Two steel stacks were knocked over, falling south, and the entire south wing of the building was distorted, leaning south, and about four feet out of plumb. In addition, all columns failed (Photos 5 and 6). The building

Photo 1 - Bldg. 3. Bomb 42. Blasted bent and folded columns.

Photo 2 - Bldg. 9. Bomb 46. Collapsed cantilever.
93 (image reversed)

evidently had light connections running north from the reentrant angle, and the two wings were broken apart by the blast of Bomb 43 (Photo 7).

f. Building 16 was a small two-story concrete building adjoining a wooden building which had been destroyed. Bombs 38 and 39 struck the concrete portion of this building, damaging the entire structure.

g. Building 18 was a steel-frame boiler house. Bomb 7 struck near the northwest corner of the building, knocking out the corner column and the two adjacent side columns. The building was distorted throughout, but not collapsed. A steel stack approximately 50 feet from the center of the bomb crater was damaged by fragmentation only to a height of 75 feet.

h. Building 33 was a steel-frame structure, the last of a series of warehouses (Buildings 32, 53, 52), and had a loading crane at the water edge. Bomb 71 struck this building, knocking down six columns and damaging the entire structure (Photo 8). One column was hurled approximately 85 feet, crashing into and reducing to ruins a small power house south of the building.

i. Building 42 was a one-story, steel-frame mill building. Bomb 75 struck in the northwest corner, knocking out four exterior columns and two interior columns. The portion of the building immediately surrounding the bomb burst was distorted, but collapse did not occur over a widespread area. Bomb 74 struck just outside the north side of the building, bending exterior columns and distorting the framing. Bomb 72 struck in the southeast corner of the building,

Photo 5- Bldg. 14. Bomb 43.

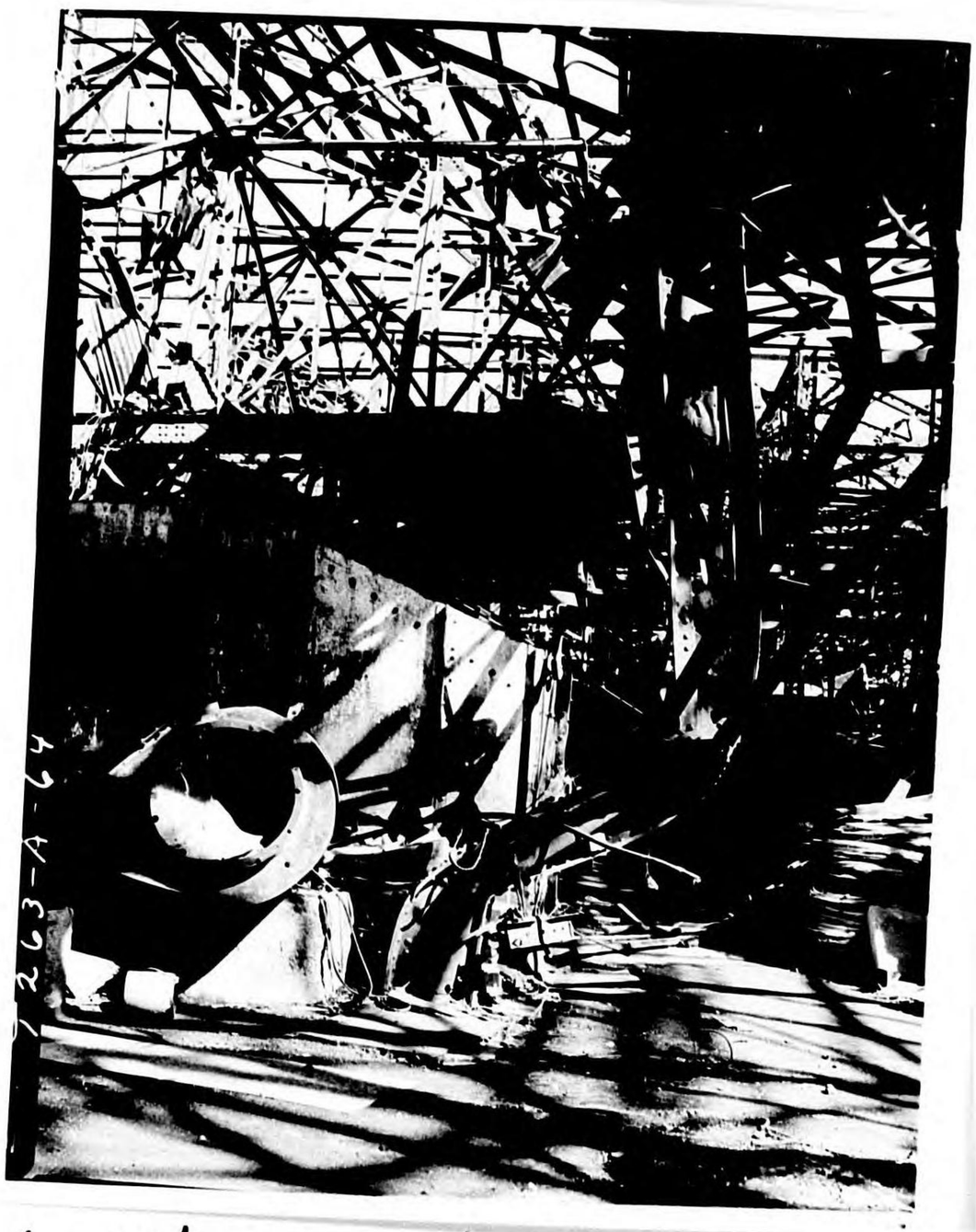


Photo 6 - Bldg. 14, Bomb 43. Column damage.

Photo 7- Bldg. 14. Bomb 13. Damage to furnace and equipment.

Photo 8 - Bldg. 33, Bomb 11. Roof damage from column.

knocking out four exterior columns and one interior column (Photo 49). Collapse of the building was confined to the immediate areas of demolished columns, but the entire structure was distorted.

j. Building 43 was a one-story, steel-frame mill building. Bomb 93 struck in this building, severely damaging two exterior columns and two interior columns. The building was also affected by the detonation of Bomb 74. Photos 10 and 11 show damage to the building, all of which was collapsed or distorted.

k. Building 51 was a large one-story, steel-frame mill building. Bomb 92 struck in the northeast corner of the building, knocking out nine exterior columns and four interior columns. Bomb 91 knocked out two interior columns. The combined effects of Bombs 91 and 92 collapsed a large area of the building (Photo 12). Bomb 77 knocked out two interior columns, causing collapse of the building in the immediate area (Photo 13). Bomb 80 struck 20 feet from the west side of the building, knocking out three external columns and collapsing the exterior bay. Bomb 78 knocked out four exterior columns and two interior columns, collapsing the building in the immediate vicinity (Photo 14). Bomb 66 collapsed an entire wing of the building (Photos 15, 16, 17). Bomb 68, which struck approximately 20 feet from the south side of the building, knocked out three exterior columns, but caused no collapse. Bomb 76 did not knock down any columns, but severely damaged the roof trusses for three bays, and distorted several columns. The entire building except for a small area on the south side was collapsed or severely distorted (Photos 18, 19).

Photo 9 - Bldg. 64, Bomb 5. Severe damage.

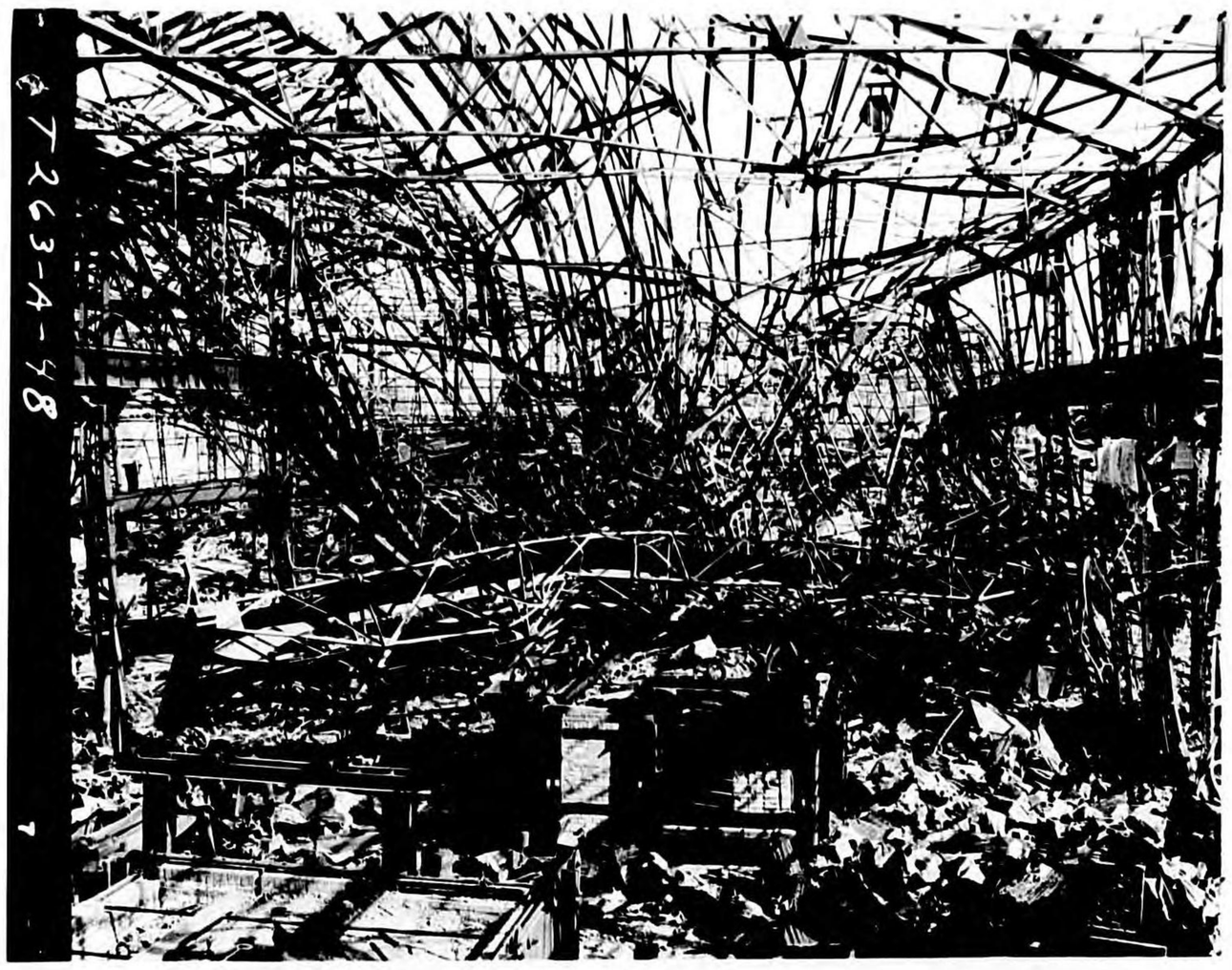


Photo 10 - Bldg. 43, Bomb 93. Overhead crane damaged.

Photo 11 - Bldg. 43, Bomb 74. Cratered

Photo 12 - Bldg. 51, Bombs 91, 92. General collapse.

Photo 13 - Bldg. 51, Bomb 77. Structural roof damage.

Photo 14 - Bldg. 51, Bombs 78, 79. Bomb crater and collapse.

Photo 15 - Bldg. 51. Bomb 66. Blast damage.

Photo 16 - Bldg. 51, Bomb 66. Detail of column damaged.

l. Building 58 was a one-story, steel-frame building with heavy crane runways. Bays were spaced at 65-foot intervals and the height of the bottom chord of the roof trusses above the brick floor was 32 feet. The structure was hit by six bombs; three were air bursts, and three cratered. Bomb 53, striking in Building 119, adjacent to Building 58, also did considerable damage.

(1) Bombs 49 and 36 were air bursts. The structure was damaged heavily from the blast of these bombs. The resultant effect of this blast was to severely damage the roof trusses in the areas of the bursts. The damage was sufficient to twist the members of the roof truss and to destroy any continuity in the bracing system. The roof framing collapsed in several bays as a result. Adjacent to this area, the alignment of the crane runway girders was disturbed and the crane rendered useless. In general, columns in the bay where each bomb detonated were smashed and twisted severely.

m. Building 62 was a one-story, steel-frame building with reinforced-concrete curtain walls tied into the exterior steel columns and beams. The building, which contained power generating equipment and was 30 feet in height to the eaves, was damaged by Bomb 67, a near miss. As the concrete exterior walls were tied into the steel columns, they transmitted the full effect of the blast into the columns, and the result was that the entire building was damaged. Photo 20 shows this effect.

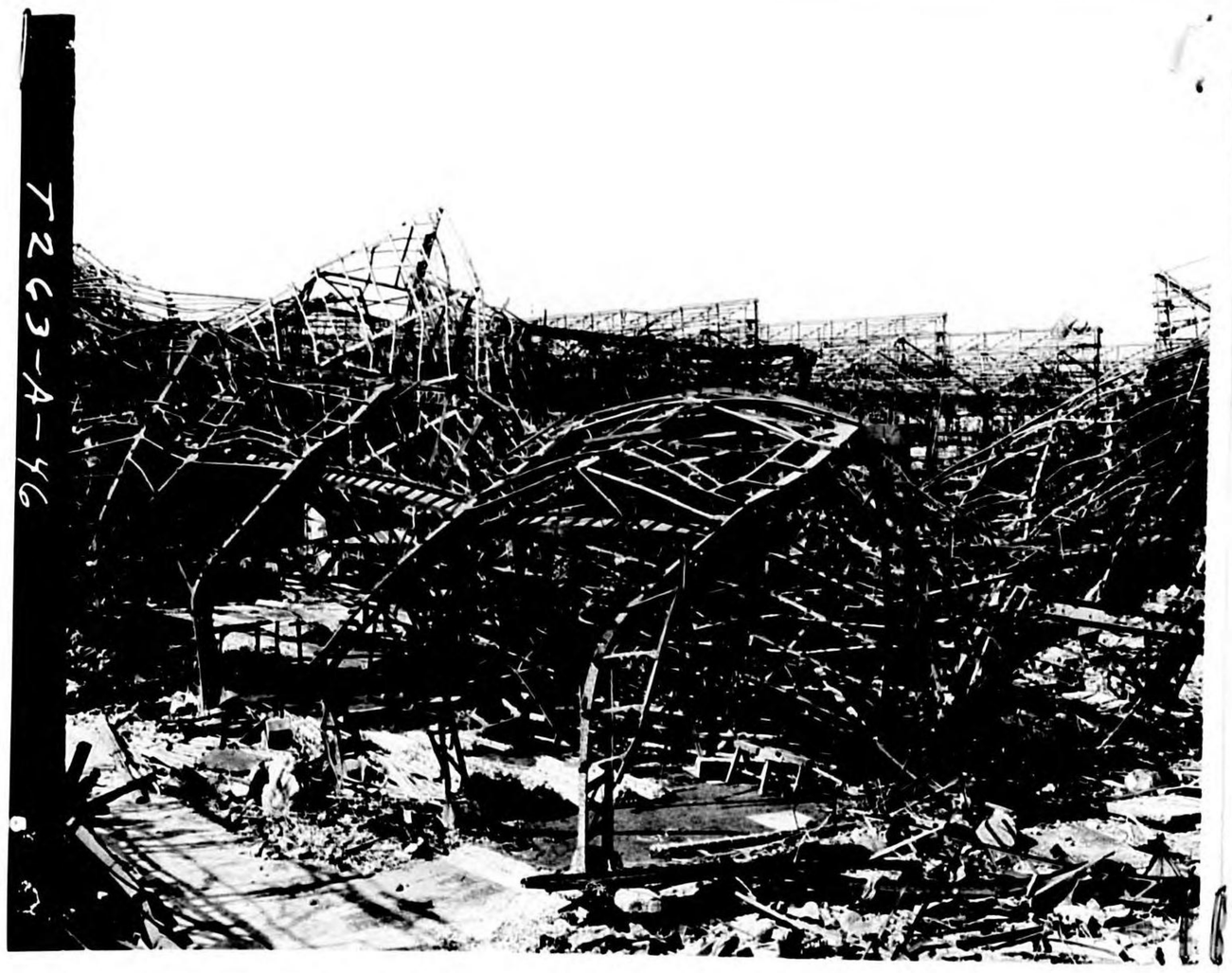


Photo 17 - Bldg. 51. Bomb 66. Exterior columns damaged by collapse.

Photo 18 - Bldg. 51. Bomb 90. Structural failure roof and columns.

n. Building 74 was a one-story, heavy, mill-type, steel-frame structure. Five bombs hit this structure, all of them being air bursts. The effect in the immediate area of a bomb burst was severe distortion of the trusses and columns. The bays adjacent to those where the bombs struck were distorted, and crane runway girders were knocked out of line. It was therefore impossible to use the overhead crane for moving materials and transportation of assemblies in the shop was definitely halted. Photo 21 shows type of collapse and distortion of steel referred to above. Photo 22 shows the collapse of structure and damage to crane runway girders. Photo 23 illustrates a similar case. Collapse of the structure shown in Photo 21 definitely precludes the possibility of any work being carried on even though damage to the material and equipment was not severe. This condition is typical of Target 263A.

o. Building 77 was a large one-story, steel-frame mill building. Bomb 64 knocked out three exterior columns and slightly damaged an adjacent stack. Bomb 63 knocked out two exterior columns and one interior column. Roof trusses and crane runways were severely damaged for two bays. Bomb 62 exploded in the roof steel, demolishing it for five bays. Surrounding columns were distorted but not knocked down. Bombs 54, 55, 57, and 58 combined to demolish or very severely distort the entire southern portion of the building (Photos 24, 25, 26, 27, 28, 29, and 30).

p. Building 82 was a one-story, steel-frame building with concrete curtain walls. Trusses were of the arch type and had a span

Photo 19 - Bldg. 51. Bomb 90. Detail of girder.

Photo 20 - Bldg. 62. Bombs 31, 32. Crushed buildings.