CHAPTER III
IDENTIFICATION OF THE SAFETY HAZARDS AND DEFINITION OF THE PROBLEMS

This chapter is divided into two major areas of emphasis: the development and presentation of data pertaining to injury incidence rates for the precast concrete products industry (SIC 3272), and the identification of those tasks performed that are hazardous to the worker. Additionally, an estimation of the cost of injuries sustained by workers in the precast concrete products industry is presented.

A. Injury and Illness Incidence Rates

The yearly compilations of occupational injury and illness data, prepared by the BLS, show that between 1976 and 1980, the precast concrete products industry had an average incidence rate of about 23 cases per 100 employees (Table III-1) [9-12]. In comparison, the incidence rate for all private sector industries averaged about 9.2 during the same interval. Workers in the precast concrete products industry have been consistently injured at a rate nearly 2.5 times the national average. Also, between 1976 and 1980 the average incidence rate for all durable goods manufacturing industries (which include SIC 3272) was about 14, which is substantially less than the rate for manufacturers of precast concrete products (Tables III-1 and III-2).

TABLE III-1
OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (SIC 3272)

Year	Average Annual Employment	Total Case Incidence Rate*	No. of Cases**	Lost Workday Cases*	Nonfatal Cases Without Lost Workdays*	Lost Workday Rate***	Actual Lost Workdays****
1976	63,100	21.4	13,503	9.1	12.3	144.7	91,306
1977	67,300	24.5	16,488	10.3	14.1	159.5	107,344
1978	72,200	24.2	17,472	11.7	12.5	165.8	119,708
1979	71,900	24.7	17,759	12.1	12.6	180.6	129,851
1980	67,200	22.3	14,986	10.4	11.9	158.3	106,378

*Number of recordable cases/100 employees.
**Calculated by multiplying the reported employment figures by the total case incidence rate and dividing by 100.
***Number of lost workdays/100 employees.
****Calculated by multiplying the average annual employment figure by the reported lost workday rate; i.e., for 1976, (63,100) x (144.7 divided by 100) = 91,305.7.
Compiled from Bureau of Labor Statistics [9 - 12].

TABLE III-2
OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES FOR
ALL DURABLE GOODS MANUFACTURING INDUSTRIES

Year	Average Annual Employment (1,000)	Total Case Incidence Rate*	No. of Cases**	Lost Workday Cases*	Nonfatal Cases Without Lost Workdays*	Lost Workday Rate***	Actual Lost Workdays****
1976	11,016	14.1	1,553,256	5.1	9.0	84.1	9,264,456
1977	11,573	14.0	1,620,220	5.4	8.6	86.4	9,999,072
1978	12,246	14.2	1,738,932	5.9	8.3	89.1	10,911,186
1979	12,772	14.2	1,813,624	6.3	7.9	95.1	12,146,172
1980	12,181	12.9	1,571,349	5.6	7.3	90.9	11,072,529

*Number of recordable cases/100 employees.
**Calculated by multiplying the reported employment figures by the total case incidence rate and dividing by 100.
***Number of lost workdays/100 employees.
****Calculated by multiplying the average annual employment figure by the reported lost workday rate; i.e., for 1976, (11,016,000) x (84.1 divided by 100) = 9,264,456.
Compiled from Bureau of Labor Statistics [9 - 12].

The incidence rates for precast concrete products are among the highest rates within the manufacturing sector (top 3%). A representative selection of the manufacturing industries is shown in Table III-3.

Table III-3 demonstrates that the occupational incidence rate per 100 employees in the precast concrete products industry was higher than those for concrete block and brick manufacturers and ready-mixed concrete, which exhibited incidence rates of 15.8 and 13.7, respectively. The incidence rate for concrete products was also substantially higher than for blast furnaces and steel mills (9.5), which is a heavy industry involving additional injury potentials attendant to the handling of molten metal.

The severity of injuries sustained by employees of the precast concrete products industry was also shown to be high. The lost workday cases and lost workdays incidence rates, represent a general measurement of the seriousness of occupational injuries and illnesses. The lost workday cases incidence rate for the precast concrete products industry (SIC 3272) in 1980 was reported by the BLS as 10.4 (Table III-1). This figure ranged from a reported high of 12.1 in 1979 to a low of 9.1 in 1976, with an average of about 10.7 for the years between 1976 and 1980 (Table III-1). The lost workday cases incidence rate for all private sector industries in 1980 was reported by the BLS as 4.0 [12] and for the durable goods manufacturing industries as 5.6 (Table III-2). Furthermore, for every 100 employees in the precast concrete products industry in 1980, a total of about 158 days were lost due to disabling injuries and illnesses (Table III-1). The

TABLE III-3
EXAMPLES OF OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES
FOR SELECTED MANUFACTURING INDUSTRIES, 1980

Manufacturing Industry	Average Annual Employment (1,000)	Total Case Incidence Rate*	Lost Workday Cases*	Lost Workdays**
Mobile Homes	45.9	27.5	11.4	173.1
Truck & Bus Bodies	38.6	24.8	10.4	129.9
Cold Finishing of Steel Shapes	N.A.	23.7	10.9	192.3
Gray Iron Foundries	125.9	23.2	11.0	171.4
Precast Concrete Products	67.2	22.3	10.4	158.3
Steel Wire	N.A.	21.4	10.1	169.6
Architectural Metal Work	31.6	19.4	8.9	113.1
Machine Tools, Metal Forming	26.8	17.2	6.8	113.7
Concrete Block & Brick	21.2	15.8	7.6	148.0
Glass Containers	69.6	15.7	9.4	180.7
Screw Machine Products	50.7	15.0	5.6	69.5
Ready-Mixed Concrete	94.7	13.7	6.2	124.0
Upholstered Household Furniture	94.7	13.4	5.1	78.8
Blast Furnaces & Steel Mills	429.3	9.5	3.4	81.6
Small Arms Ammunition	N.A.	6.3	2.9	43.4

* Number of recordable cases/100 employees.
** Number of lost workdays/100 employees.
Compiled from Bureau of Labor Statistics [12].

industries comprising the manufacturers of durable goods reported a substantially lower rate of about 91 days lost per 100 employees (Table III-2).

About 46%[1] of the workers injured in reported accidents in the precast concrete products industry between 1976 and 1980 lost time from their jobs, an average of about 15 days per case in 1980.[2]

B. Costs of Injuries

The total cost of work injuries is difficult to develop due to incomplete recording and lack of data on both direct and indirect costs. Estimates can

[1]Average percentage of total recordable cases reported as lost-time cases by the BLS (Table III-1).

[2]Lost workdays/lost workday cases = lost workdays rate divided by lost workday cases; i.e., for 1980 (Table III-1),

$$\frac{158.3}{10.4} = 15.2 \text{ lost workdays/lost workday case.}$$

be made, however, which reveal the magnitude of the problem. Best available workers' compensation data from 46 States [13-21] reported a total of 9,335 medical and indemnity compensation cases during 1977 (the most current year reporting reasonably complete data) with actual paid claims totaling $30,855,454 or an average of about $3,305 per case. This averages about $595[1] per production worker in 1977 dollars. Although the estimates of direct costs of worker injuries are not precise, they do reflect the magnitude of the problem.

Estimates derived from National Safety Council [22] data indicate that full costs of work-related accidents are more than 3.4 times the direct wage loss and medical expense costs. Since the indemnity payments are normally less than wage loss, the real accident costs for the precast concrete products industry are estimated to exceed $105 million per year (3.4 x $30.9 million). In addition to medical and indemnity expenses, estimates of the real cost of accidents include:

- o Cost of wages for lost worktime by injured employee(s), other than workers' compensation payments
- o Cost of wages for supervisor's time required for activities necessitated by the injury
- o Cost of wages for decreased output of injured employee(s) after return to work
- o Cost of learning period for new employee(s)
- o Cost of time spent by higher supervisory and clerical employees on investigations or in processing compensation application forms
- o Net cost to repair, replace, or straighten up material or equipment damaged in an accident
- o Extra cost for overtime work necessitated by an accident
- o Cost of wages for lost worktime by employee(s) not injured
- o Cost of litigation resulting from OSHA investigations
- o Uninsured medical cost borne by company.

C. Identification of the Hazards

The preceding section of this chapter defined the magnitude of the safety problem in the precast concrete products industry. The next step in a systematic approach to effectively lowering worker accident/injury exposure is the identification of how workers are injured while performing the tasks required to produce precast concrete products.

1. The Supplementary Data System (SDS)

Currently, occupational accident and injury information from participating states, which is taken from employers' first report of injury forms,

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[1]Production workers comprise about 77% of the total work force for this industry [3]. Seventy-seven percent of the reported 1977 employment figure of 67,300 (Table III-1) is 51,821 production workers. Compensation losses of $30,855,454 divided by 51,821 production workers yields about $595 per production worker.

is compiled and reported by the BLS Supplementary Data System (SDS) [23, 24]. The SDS is intended to alert users to patterns and relationships of injury causal factors. The information is entered into each of four major groupings:

- o Source of injury
- o Type of accident
- o Nature of injury
- o Part of body affected.

The frequency and percentage distribution of the injuries reported to SDS by the precast concrete products industry for the years 1976 - 1979 are presented in Table III-4 for each of the groupings mentioned above. The percentages do not indicate that one category represents a greater hazard than another, since data clarifying worker exposure are not available.

2. Accident/Injury Analysis

The SDS data are limited when used in the analysis of a specific industry because the "source of injury" category contains subcategories which do not apply to the industry under study, and does not contain subcategories which are related to industry-specific tools and equipment. Further, the "source of injury" reported is the object most responsible for causing the injury. Thus, if a worker falls from a ladder and fractures his leg on the plant floor, the "source of injury" is the floor, which probably contributed little to the actual cause of the accident.

Despite the constraints, the SDS data reported by the precast concrete industry for 1976 - 1979, which included 15,208 injuries, were analyzed to identify specific industry hazards. The analysis included 37 categories that identified injury sources within precasting operations.

The results of the cross-analysis of the SDS data are summarized in Table III-5. The total number of accidents/injuries appears in the "Source of Injury" column. The numbers associated with "Type of Accident," "Nature of Injury" and "Body Part" do not agree with the "Source of Injury" totals since the figures given are merely the most frequent subcategories.

3. Analysis of Accident Case Histories

For a more complete understanding of accident/injury causal factors, full text copies of employers' first report of injury forms filed by SIC 3272 industries were requested from all 50 States. In most instances, the state agencies were not able to provide information. However, 10 States [1] did provide copies of 2,250 first report of injury forms from

[1] California, Hawaii, Iowa, Kentucky, Michigan, Montana, Maryland, Washington, Wyoming, and Vermont.

TABLE III-4

SUMMARY OF SUPPLEMENTARY DATA SYSTEM ACCIDENT/INJURY PROFILE, 1976-79, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

TYPE OF ACCIDENT	No. of Accidents	(%)	NATURE OF INJURY	No. of Accidents	(%)
Struck By or Against	5,187	(34.1)	Amputation	115	(0.8)
Falls	2,210	(14.5)	Burns (Heat)	297	(1.9)
Caught In or Between	1,523	(10.0)	Burns (Chemical)	175	(1.1)
Rubbed/Abraded Against	767	(5.0)	Contusions, Bruises	2,403	(15.8)
Bodily Reaction	762	(5.0)	Cuts, Lacerations	2,133	(14.0)
Overexertion	3,220	(21.2)	Fractures	1,647	(10.9)
Contact w/Temp. Extremes	295	(1.9)	Scratches, Abrasions	893	(5.9)
Contact w/Caustics	599	(4.0)	Sprains, Strains	4,724	(31.1)
Motor Vehicle Accident	162	(1.1)	All Other Occ. Diseases	1,376	(9.0)
All Other Classifiable	118	(0.8)	All Other Classifiable	212	(1.4)
Nonclassifiable	365	(2.4)	Nonclassifiable	1,233	(8.1)
Total	15,208	(100)	Total	15,208	(100)
PART OF BODY INJURED			**SOURCE OF INJURY**		
Eyes	1,275	(8.4)	Boxes, Barrels, Containers	793	(5.2)
Head, Neck	836	(5.5)	Chemicals	307	(2.0)
Fingers	2,083	(13.7)	Handtools	1,247	(8.2)
Upper Ext., Not Fingers	2,135	(14.0)	Machines	845	(5.6)
Back	2,961	(19.5)	Metal Items	3,212	(21.1)
Trunk, Not Back	1,478	(9.7)	Vehicles	953	(6.3)
Lower Extremities	3,483	(23.0)	Wood Items	589	(3.9)
Multiple Body Parts	670	(4.4)	Working Surfaces	1,797	(11.8)
Body System	161	(1.0)	All Other Classifiable	4,977	(32.7)
Nonclassifiable	126	(0.8)	Nonclassifiable	488	(3.2)
Total	15,208	(100)	Total	15,208	(100)

Compiled from Bureau of Labor Statistics [24].

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Bodily Motion (no lifting, pushing, pulling)	726	Bodily reaction (slips, loss of balance, reaching, bending)	689	Sprain, strain	601	Back	283
						Ankle	157
						Knee	99
Chemicals (acids, alkalis, moist concrete)	307	Contact with caustics	246	Chemical burns	127	Eye	88
				Dermatitis	56	Multiple parts	52
				Systemic poisoning	38	Body System	41
						Hand	31
Coal/oil products (form release agents, lube cutting oil, safety solvents)	89	Contact with caustics	53	Dermatitis	33	Hand	27
		Contact temperature extremes	27	Burns	26	Eye	12
				Chemical burns	14	Multiple parts	9
Concrete aggregate (sand, cement, gravel)	842	Overexertion	203	Sprain, strain	225	Eye	178
		Struck by falling obj.	152	Abrasion	136	Back	151
		Rubbed or abraded by foreign material	115	Contusion	131		
Concrete Items	349	Overexertion	129	Sprain, strain	122	Back	83
		Struck by falling obj.	68	Contusion	71	Finger	63
		Caught in, under, or between	61	Fracture	52	Trunk	41
Concrete Mixers	125	Caught in, under, or between	60	Cut, laceration	28	Finger	44
				Sprain, strain	25	Hand	18
		Struck against stationary object	16	Fracture	24	Back	13
				Contusion	21		
		Overexertion	15				
		Struck by	13				

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Concrete pipe	137	Overexertion	73	Sprain, strain	71	Back	49
		Caught in, under, or between	19	Contusion	19	Trunk	21
				Fracture	14	Finger	21
Containers (bags, boxes, bundles, reels, rolls)	714	Overexertion	444	Sprain, strain	410	Back	310
				Contusion	93	Trunk	102
						Finger	72
Conveyors (gravity, powered)	115	Caught in, under, or between	70	Contusion	23	Finger	34
				Fracture	22	Hand	14
		Overexertion	13	Sprain, strain	19	Back	12
				Cut, laceration	17	Foot(not toes)	12
Cranes	99	Struck by	30	Contusion	29	Finger	17
		Caught in, under, or between	18	Fracture	18	Trunk	16
				Sprain, strain	15	Back	12
		Overexertion	12	Cut, laceration	10	Head	11
		Struck against stationary object	10				
Crowbars	85	Struck by	30	Contusion	25	Back	24
		Overexertion	26	Sprain, strain	24	Finger	12
		Struck by falling object	10	Cut, laceration	15	Trunk	9
				Fracture	12		
Doors, gates	90	Overexertion	27	Sprain, strain	27	Finger	18
		Struck by falling obj.	18	Contusion	20	Trunk	16
		Caught in, under, or between	17	Fracture	16	Back	14
				Cut, laceration	13		
		Struck by	12				
		Struck against stationary object	10				

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Flame/fire	81	Contact temperature extremes	76	Burn	76	Multiple parts	20
						Hand	10
Forklifts	296	Caught in, under, or between	91	Contusion	80	Finger	59
				Fracture	72	Foot(not toes)	42
		Struck by	71	Sprain/strain	51	Back	33
		Overexertion	30	Cut/laceration	34		
		Struck against stationary object	30				
Forms	110	Overexertion	35	Sprain, strain	38	Finger	28
		Struck by falling object	27	Contusion	30	Back	27
				Cut, laceration	14		
		Caught in, under, or between	20				
Hammers, powered	81	Overexertion	29	Sprain, strain	27	Back	18
		Struck by	20	Contusion	16	Finger	18
		Struck by falling object	10	Fracture	13		
				Cut, laceration	11		
Hammers	299	Struck by	184	Contusion	133	Finger	95
		Overexertion	47	Sprain/strain	44	Hand	48
				Fracture	42		
Hand Tools, powered (drills, grinders, saws and welding tools)	228	Struck by	77	Cut, laceration	86	Finger	66
		Overexertion	42	Sprain, strain	44	Hand	25
		Caught in, under, or between	24	Fracture	25		
				Contusion	23		

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Hand tools, non-powered (blow torches, chisels, ropes and chains, saws, screwdrivers)	345	Struck by	126	Cut, laceration	113	Finger	87
		Overexertion	87	Sprain, strain	91	Back	41
				Contusion	57	Hand	40
Hoisting apparatus (air hoists, chain hoists, electric hoists, jacks)	154	Caught in, under, or between	42	Contusion	41	Finger	50
				Fracture	32	Back	18
		Struck by falling object	34	Sprain, strain	27		
				Cut, laceration	26		
		Struck by	29				
		Overexertion	23				
Lumber and other wood items	589	Overexertion	221	Sprain, strain	219	Back	154
		Struck by falling object	125	Contusion	114	Finger	87
				Fracture	92	Trunk	85
		Struck by	75				
Machinery (cage roller, concrete extruding, concrete saw, pipe spinning, press brake, rebar bending, rebar cutting)	720	Caught in, under, or between	302	Cut, laceration	197	Finger	287
				Contusion	131	Hand	97
		Overexertion	90	Fracture	117		
		Struck against moving object	75	Sprain, strain	100		
Mechanical power transmission apparatus (chains, ropes, cables; drums, pulleys)	135	Caught in, under, or between	51	Cut, laceration	41	Finger	46
				Sprain, strain	26		
		Struck by	30	Contusion	21		
		Overexertion	26	Fracture	15		

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE,
1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Nails	146	Struck against stationary object	113	Puncture	137	Foot(not toes) Hand	106 15
Particles (unidentified)	323	Rubbed or abraded by foreign material	256	Abrasion	271	Eye	314
Reinforcement bars	268	Overexertion Struck by falling object Struck by Struck against stationary object	68 60 44 38	Sprain, strain Cut, laceration Contusion Fracture	81 53 51 37	Back Finger Trunk	52 48 36
Reinforcement other than bars and steel forming (bolts, nuts, plates, rods, shapes, wire strand)	2,284	Overexertion Struck by falling object Struck by Struck against stationary object	465 440 332 281	Cut, laceration Sprain, strain Contusion Fracture Abrasion	645 461 363 266 230	Finger Back Eye	360 336 310
Shovel	109	Overexertion	91	Sprain, strain	90	Back Trunk	78 11
Steel pipe	404	Overexertion Struck by Caught in, under, or between Struck by falling object	134 71 63 56	Sprain, strain Contusion Fracture Cut laceration	145 97 45 43	Back Finger	105 74

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Structures (not floors, working surfaces, or walkways)	129	Overexertion	27	Contusion	35	Back	28
		Caught in, under, or between	26	Sprain, strain	33	Finger	22
				Cut, laceration	21	Trunk	13
		Fall on same level against object	23	Fracture	18		
		Struck against stationary object	17				
		Struck by falling object	16				
Tank bins	79	Overexertion	21	Sprain, strain	25	Finger	15
		Caught in, under, or between	21	Contusion	15	Back	15
				Cut, laceration	14	Trunk	9
		Struck by falling object	9	Fracture	9		
		Struck against stationary object	8				
Vehicles (industrial, tractors and other powered vehicles)	110	Caught in, under, or between	33	Sprain, strain	29	Trunk	23
				Contusion	24	Finger	14
		Overexertion	15	Fracture	18	Back	12
		Occupant in motor vehicle accident	14				
		Struck by	13				
Vehicles (highway)	377	Occupant in motor vehicle accident	140	Sprain, strain	97	Trunk	74
				Contusion	95	Multiple parts	53
		Struck against stationary object	52	Cut, laceration	55	Back	52
				Fracture	47	Finger	40
		Caught in, under, or between	39				

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Concluded)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Welding machines (electric)	167	Contact with radiation	127	Welder flash	110	Eye	156
				Radiation effects	37		
Wheelbarrows and handtrucks	170	Overexertion	84	Sprain, strain	90	Back	54
		Caught in, under, or between	29	Contusion	34	Trunk	23
				Fracture	18	Finger	20
		Struck by	19				
Working/walking surfaces	1,797	Fall to work surface	540	Sprain, strain	776	Back	329
		Fall to level below	307	Contusion	307	Ankle	284
		Fall from vehicles	299	Fracture	273	Trunk	230
						Knee	185
Wrench	100	Overexertion	43	Sprain, strain	40	Finger	23
		Struck by	36	Contusion	21	Trunk	22
		Struck by falling obj.	10	Cut, laceration	13	Back	15
				Fracture	12		
Miscellaneous classifiable	1,541	Overexertion	514	Sprain, strain	492	Back	378
		Struck by falling object	198	Contusion	222	Finger	174
				Cut, laceration	171		
Nonclassifiable	488	Overexertion	96	Sprain, strain	145	Back	145
						Trunk	67
Total incidents	15,208		10,123		11,272		7,987
(%)	100%		67%		74%		53%

Compiled from U.S. Department of Labor Supplementary Data System (SDS) unpublished accident and injury data for 1976 - 1979 [24].

recent years (1977 to 1981). Of the 2,250 accident/injury reports, 1,319 (about 59%) were included in the analysis. Of these 1,319 injuries, 34 resulted in a fatality. Those reports not included in the analysis primarily contained injury information, and were found to contain insufficient data to determine accident causal factors.

A preliminary analysis of these accident case histories was performed to determine whether the accident data base was indicative of accidents occurring to workers in precasting operations nationwide. Each report was categorized by type of accident ("struck by," "caught between," "fall"). Numerical and percentage values of the "type of accident" categories were compared to the national SDS figures (Table III-4). The comparison (Table III-6) shows markedly similar ratios; e.g., the percentage of "struck by" and/or "caught between" accident types are reasonably consistent in both data bases. Because of the similarities between data from the sources considered, it was concluded that the accident/injury case histories used in this report are representative of accidents that occur to workers in the precast concrete products industry.

The first step in the analysis was the identification of the specific task, tool, type of material, piece of equipment, or plant area most closely associated with the accident in each case. This procedure made possible more precise and industry-specific classification than the SDS "Source of Injury" category could provide. Then, a causal factor was identified in each case (e.g. improper tool use, lack of personal protective equipment, lack of adequate guarding, improper materials handling procedures). The task/tool/equipment factors and accident causal factors were then cross-indexed to allow the identification of problem areas.

The following narrative descriptions of how workers are injured in the precast concrete products industry are based on analysis of SDS data (Table III-5) and the accident case histories. The percentage that follows each category or factor is the percentage of the total number of accidents (1,319) from the case history analysis.

Section a covers general accident factors; i.e., tasks, tools and items of equipment that are not specific to the precast industry. Section b presents factors that are specific to precasting processes. Section c describes accident causal factor patterns, groups of factors which may encompass several task/tool/equipment categories. Essentially, the organization of sections a, b, and c is followed in the presentation of the recommendations in Chapter IV.

a. General Accident Factors

The following narrative paragraphs describe the ways workers are injured due to task/tool/equipment factors which are not necessarily specific to the precast concrete products industry.

TABLE III-6
COMPARISON OF SDS ACCIDENT/INJURY CLASSIFICATION WITH THE ANALYSIS OF ACCIDENT CAUSAL FACTORS FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

Type of Accident	No. of Accidents	(%)*	No. of Accidents	(%)**
Struck By or Against	5,187	(34.1)	508	(38.5)
Falls	2,210	(14.5)	268	(20.3)
Caught In or Between	1,523	(10.0)	152	(11.5)
Rubbed/Abraded Against	767	(5.0)	11	(0.8)
Overexertion	3,220	(21.2)	258	(19.6)
Contact w/Temp. Extremes	295	(1.9)	22	(1.7)
Contact w/Caustics	599	(4.0)	67	(5.1)
Motor Vehicle Accidents	162	(1.1)	16	(1.2)
All Other Classifications (including nonclassifiable)	1,245	(8.2)	17	(1.3)
Total	15,208	(100.0)	1,319	(100.0)

*Taken from Table III-4 [Note: The SDS classifications "Bodily Reaction" and "Nonclassifiable" were not used in the analysis; however, their totals are included under "All Other Classifications."]

**Analysis of 1,319 accident case histories from OSHA accident investigations and employers' first report of injury forms.

Although these general factors are arranged in order from highest to lowest percentage of occurrence, this grouping does not suggest that one factor represents a more significant hazard than another, since no data clarifying worker exposure are available.

(1) Materials Handling (28.0%)

(a) Manual (19.9%)

(i) Lifting (9.6%)

The act of lifting items resulted in nearly 10% of the injuries in the industry. Approximately 81% of these incidents involved overexertion to the back while manually handling materials. Loss of grip accounted for 9% of the lifting accidents. These usually resulted in injuries either to the lower extremities when the load was dropped or to the

fingers when the load was set down with inadequate clearance.

(ii) Mechanical Materials Transport (7.1%)

This category presents a variety of tasks associated with materials handling as well as a variety of other accident causal factors. Included in this activity are interface of manual and mechanical load handling procedures performed on flatbed trucks and the manual transfer of materials to forklifts. Manual materials handling and gripping of materials accounted for 27% of the injuries in approximately the same causal/injury breakdown as cited in the discussion of the lifting category. Improper stacking and binding of materials was reported to be the cause of about 27% of these accidents, usually from the material falling onto the worker. An additional 12% of the accidents occurred to workers attempting to climb onto the transport vehicle or the material itself when access was not provided.

(iii) Carrying and Holding (1.8%)

This category of activity includes the manual tasks, by one or more workers, of carrying or handling materials. Many of the injuries were sprains and strains that usually occurred from overexertion during the procedure. About 29% of the injuries were attributed to falls from working/walking surfaces which were wet and/or slippery and cluttered with tripping hazards. Inadequate interworker coordination on multiperson tasks accounted for 25% of the accidents. These incidents frequently occurred when a worker would prematurely drop his portion of the load (See Table III-5, "Concrete aggregate" and "Containers").

(iv) Wheelbarrows and Handtrucks (1.4%)

About one-third of the accidents that occurred with hand transport systems were attributed to working/walking surfaces which were either cluttered with tripping hazards or were wet and/or slippery. Wet, slippery surfaces increase the potential hazard when pushing or pulling items. Most of the remaining accidents were attributable to manual materials handling problems, including improper worker position and improper lifting techniques.

(b) Mechanical (8.1%)

(i) Hoists and Cranes, Including Pendant-Operated (4.4%)

The injury analysis indicated the most serious accidents and injuries occurred during tasks involving the use of cranes and hoists. Fourteen (41%) of the reported fatalities happened during craning activities. The fatal accidents were most frequently related to rigging practices and/or overloading. Workers were struck by dropped loads, material falling off the loads, as well as falling hoist components during crane failures. Two fatalities occurred when workers were struck by cranes moving a suspended load. Another worker was fatally injured when struck by a load suspended by a straddle carrier.

The nonfatal injuries followed a similar pattern of accident causal factors. Although a number of incidents involved fingers being caught between suspended loads and stationary objects or in the rigging material (Table III-5, "Cranes" and "Hoisting apparatus"), most of these accidents were caused either by inadequate rigging and/or crane overload or by the movement of the crane or load. In these instances, although the injuries were less severe, the potential for fatal accidents was evident.

(ii) Forklifts (1.9%)

Forklifts are used throughout the industry to move material as well as finished products. Forklift operations accounted for about 12% of the fatalities. These accidents usually occurred to coworkers that were not seen by the forklift operator. One fatality resulted from overloading of the lift's capacity, causing the forklift to tip and crush the operator. Accidents that occurred during lift operations that were attributable to improper stacking, storage, or binding techniques are listed in other categories (e.g., Mechanical Materials Transport and Material Storage).

Operating errors (running into or over objects, tripping, and speeding) were the causal factors cited in many of the accident reports. Inadequate visibility in the work area and inadequate audibleness of the forklift in motion contributed to

the accidents occurring to coworkers. Table III-5 indicates that workers suffered injuries to the fingers and feet by being caught in or struck by the forklift.

(iii) Hoists, Chain (0.8%)

Rigging practices were again found to be commonly at fault in accidents involving mechanical chain hoists. Hand operation of the hoists necessitated close proximity to the hoisted loads and contributed to employee exposure to hoist or rig failure.

(iv) Conveyors (0.6%)

Although only 0.6% of the accidents involved conveyors, they accounted for nearly 9% of the fatal injuries. These accidents occurred when the conveyor jammed and the operator/worker attempted to free the jam without deenergizing and locking out the system. Workers were caught by or in exposed moving portions of the conveyors. Lack of guarding of exposed moving parts and/ or nonlimiting access to the area were cited as contributing factors to the accidents. Similarly, the nonfatal incidents usually involved the upper extremities being caught in or between the conveyor mechanisms as shown in Table III-5.

(v) Front-End Loaders (0.4%)

Front-end loaders are normally used in the movement of bulk materials (aggregate, sand) from the stockpile to the mixing area. There were two types of accidents involved: those that occurred to the operator during the process of getting off the loader (access), and those that resulted in coworkers being injured. In the latter accidents, the injured workers were in the path of travel of the loaders and were either caught between it and another object or they were run over by the moving equipment. Inaudible or nonfunctioning backup alarms as well as operator inability to see coworkers were cited as contributing factors.

(2) Handtools (11.5%)

(a) Handtools, Powered (5.8%)

Nearly all of the injuries attributable to the use of powered handtools resulted from deficiencies in three

areas: guarding, tool usage, and lack of eye protection.

The injury analysis revealed that most eye injuries occur during use of grinders. The remaining grinder-related accidents were the result of inadequate or non-existent guards that failed to prevent finger contact or protect against stone disintegration. In some instances, while using the grinder, part of an employee's body, usually the thigh, came into contact with the abrasive stone. In the SDS accident/injury analysis (Table III-5), eye injuries occurring during grinding activities were not listed with grinders; rather, they were tabulated in the "Particles" category.

Although lack of eye protection contributed to 20% of the powersaw injuries, the single, consistent accident causal factor was inadequate or nonexistent saw blade guards (58%). Included in this category were instances when anti-kickback devices were not used during ripping operations. The majority of injuries resulting from lack of saw guards were lacerations and amputations of fingers. Two eye injury accidents also occurred while using concrete saws.

The accident analysis shows that most accidents during drilling tasks occurred when large-diameter (1-inch or larger) holes were drilled through forms. The drill bit would bind and the drill motor would continue to turn, catching the workers' hands between the motor and adjacent items, usually the form. This may be interpreted as improper tool use or as improper worker position relative to the task.

Lack of eye protection accounted for one-third of the reported injuries that occurred while using airhammers. In some instances, airhammers were used in awkward positions, resulting in strains and sprains of the back and/or arms. In three instances, the airhammer was positioned for use too close to the edge of either a form or product, and the worker's hands or fingers were caught. Table III-5 indicates that powered hammers as a source of injury resulted in injuries to the back because of worker overexertion and to fingers that were struck by the hammer.

(b) Handtools, Unpowered (5.7%)

Strains of the back are the most prevalent injury associated with shoveling activities. The injury reports indicated that many injuries were associated with overloading the shovel, twisting the body, and handling the

load from too great a distance (see Table III-5, "Shovel" and "Concrete aggregate").

The activity of "prying" is frequently performed by workers dismantling forms and separating the product from the form. Referring back to Table III-5, 47% of the accidents involving crowbars, a tool routinely used for prying, were classified by the SDS as "struck by" accident types resulting in contusions and sprains and strains. The most frequent areas of the body injured were the back and finger. The analysis of the accident cases showed that 65% of the prying accidents were reported to be caused by improper worker position relative to the task. When the prying implement slipped, the tool usually either struck the worker or the worker slipped and fell. Most of the remaining accidents involving prying activities resulted from improper tool use. Shovels were commonly misused by workers attempting to pry forms loose from cured concrete.

The most common type of accident that occurs during the use of handtools is the "struck by" variety (Table III-5), most frequently caused by improper position of the worker relative to the task. The analysis indicated that glancing blows are commonly cited as the cause of the accident. Fingers and hands were struck by hammers and sledge hammers when part of a worker's body was in the path of the deflected hammer movement. Use of improper tools contributed to 25% of the hammering accidents. Typical cases involved shovels, wrenches, and boards used to hammer forms, nails, or other materials.

The analysis indicated that fingers were the most frequent part of the body injured while using a wrench; usually, the wrench slipped off a nut or bolt. The injury reports indicated that many accidents associated with tool slippage were caused by improper tool usage (size and/or adjustment). The accident probability was compounded by improper worker position relative to the task. The information in Table III-5 indicates that workers suffered sprains and strains from excessive physical effort while using wrenches. This could possibly be a result of using wrenches of improper size for the job.

(3) Worker Proximity to Operations (7.4%)

(a) Walking Through Work Areas (6.3%)

In a number of instances a specific task or activity description was not included in the accident report. The

worker was "walking" in an unspecified section of the plant. Almost 29% of these injuries were nail punctures of the foot. More than 45% were falls to the working/walking surface caused by slipping on wet, slippery surfaces or tripping on material, usually pieces of concrete debris, rebar, welding stubs, or leads.

(b) Working Near Operations (1.1%)

This category includes workers injured by tasks or operations that were independent from their assigned tasks. The most prevalent accident/injury in this grouping was flash burns from nearby welding operations. In fact, 45% of the reported flash burns occurred to workers who were not involved in the actual welding process. Two workers were also injured by particles from nearby metal grinding operations.

(4) Welding, Cutting, Burning (4.6%)

The data indicated most of the injuries (54%) that occurred in welding, cutting, and burning activities were typified by foreign bodies in the eye that were caused by slag or weld "pop." In these instances, the workers were not wearing eye protection. An additional 20% of the injuries were flash burns to the workers performing the welding operations. In these cases, the worker was usually inadequately protected because cutting goggles were being used instead of approved welding hoods during short welding operations. The SDS data (Table III-5) indicate that welders flash burns account for 1% of the industry's injuries.

(5) Chemical Handling (4.6%)

More than 44% of the incidents in this category involved chemical dermatitis caused by direct skin contact with moist concrete. Concrete burns, most commonly to hands and forearms, were usually sustained during casting or cleanup operations. In a few instances, concrete dermatitis developed during the dry mixing of the concrete. Lack of respiratory protection accounted for four of the incidents involving cement dust.

Lack of personal protective equipment, mostly eye protection, was a contributing factor in 30% of the chemical handling injuries. Workers received eye injuries during mixing, casting, and cleanup operations. Lack of eye protection was also a causal factor in four eye injuries that occurred during spray application of form release agents. Sprayers were overpressurized by misapplication of unregulated systems, resulting in explosions of the canisters in two instances.

(6) Materials Storage (4.5%)

Analysis of the accident data indicates that 46% of the materials storage accidents were the direct result of improper stacking and/or binding procedures. Product storage (multi-level) stacks were not stable enough to support their height and weight. Most of the injuries occurred while workers were in the process of adding additional material to the stack. The second most frequent cause of injury in materials storage activities was related to manual materials handling and improper gripping of the load. Fingers and toes were most at risk during these activities.

(7) Ladders and Scaffolds (3.9%)

One-fourth (25%) of the ladder/scaffold accidents were directly attributable to working from makeshift platforms (improper tools). The accidents that occurred on makeshift scaffolds were usually falls to the level below. Two scaffold accidents (one fatal) involved scaffolds with inadequate or nonexistent guardrails. Slippery (wet, icy) conditions on the ladders/scaffolds were cited in more than 22% of the accidents, mostly resulting in falls to the working surface of the scaffold. Inadequate securing of ladders against slipping (chocking, blocking, or tying) caused six of the accidents that were falls to levels below. In two instances, ladders were placed in the paths of moving vehicles (forklift, crane), resulting in collisions and serious injuries.

(8) Chipping/Cleaning (2.9%)

The majority of injuries that occurred to workers cleaning forms, products, or mixers probably would have been prevented by eye protection. The second largest accident causal factor in chipping/cleaning tasks was inadequate or nonexistent access to the area; makeshift worker platforms were common.

b. Process-specific Accident Factors

The following narrative paragraphs describe the ways workers are injured due to task/tool/equipment factors specific to the precasting processes. In the absence of data clarifying worker exposure, the percentage ranking is not intended to imply that any one factor represents a more significant hazard than another.

(1) Form Work (7.2%)

(a) Form Assembly/Disassembly (4.9%)

Form assembly and dismantling are frequently manual procedures that involve physical manipulation of form

components. Consequently, the accident/causal factors associated with form assembly primarily fall into the categories that typify physical procedures; e.g., the worker's position relative to the task, and gripping and handling form components. Many of the injuries that occurred in form assembly tasks were sprains and strains of the back, and injuries to the fingers. In two instances, workers were struck by form sections being turned by overhead hoists. Inadequate chocking and bracing of form sections during assembly or stripping contributed to many of the more serious injuries. In the instances when the form component adhered to the cured concrete, workers were struck by or caught beneath a portion of the form that was suddenly released and fell. Additional information concerning injuries resulting from form work can be found in Table III-5, "Forms" and "Lumber".

(b) Form Closing (1.1%)

Included in this activity are the tasks associated with closing (assembly) of prefabricated multiuse form components. Binding and unexpected release of the inner cores or outer forms of pipe molds typified most of the accidents in this group. "Caught between" accidents resulting in injuries to the fingers were the most common.

(c) Form Stripping (1.2%)

The most common cause of accidents in form stripping activities involved improper tool usage. Most frequently, these accidents resulted from using shovels as levers to pry form walls loose from the cured concrete.

The most serious accidents, one of which was fatal, involved inadequate or nonexistent cribbing or blocking of form walls. The fatality resulted when a worker crawled under a portion of form wall no longer integral to the remainder of the form or the product to determine where the form was still "hung up." The form wall fell while the worker was under it.

(2) Reinforcing (4.3%)

(a) Tying Resteel (1.5%)

With the exception of hands and fingers that were lacerated during the handling of the resteel, most workers (40%) were injured in accidents involving access to the forms and/or slippery working surfaces. The actual placing of strand differed little in accident

causal patterns from other forming and casting operations. Additional injury information is contained in Table III-5, "Reinforcement".

(b) Stressing (1.5%)

The accidents that most frequently occurred during stressing operations were similar to accidents which occurred during other forming and casting operations. Lack of eye protection accounted for more than 32% of the incidents--most of these caused by metal particles (scale) flicking off during the handling of the strand. The more serious accidents occurred during the actual stressing procedure and involved inadequate or nonexistent means for controlling employee access to the stressing area.

The high tension stretching of the steel strand poses a somewhat unique hazard to the industry. Since stressing is used in only about 10% of the precasting plants, the relatively small number of accident cases (19) may not reflect the frequency of accidents occurring in the actual stressing operation. The static forces contained in stressed strand are potentially hazardous. When these forces are accidentally released, workers within range of strand whiplash are exposed to potentially serious injury.

(c) Metalworking Machinery (1.3%)

Metalworking machinery (cage rollers, rebar benders and cutters, press brakes) are used in the precast concrete products industry to manufacture the shapes necessary for reinforcing concrete. More than 1% of the accidents that occurred to precast concrete workers happened during metalworking tasks related to the production of the reinforcing steel shapes. Inadequate and nonexistent guarding was the major accident causal factor associated with metalworking tools and operations. Cage rollers (0.6%) accounted for nearly one-half of these accidents. Failure to guard in-rolling nip points on the cage rollers resulted in two of the more serious injuries. Other accidents occurred while handling the metal items during bending, cutting, or rolling operations. Frequently, these were either lacerations of the hands caused by sharp edges or crushing injuries due to hands-on manipulation of the metal while the machine was in operation. Additional information concerning injuries from machinery can be found in Table III-5.

(3) Oiling

Analysis of the accident reports failed to identify accidents which were specifically ascribed to the oiling process. Factors which may influence the occurrence of accidents during oiling procedures include contact with form release agents, access to forms or product, and working/walking surfaces. These factors are discussed in the paragraphs on Chemical Handling in section a, and in the paragraphs on Personal Protective Equipment, Access, and Working/Walking Surfaces in section c.

(4) Concrete Mixing and Transport (2.6%)

(a) Concrete Mixing (1.8%)

Failure to lockout or tagout an energy source before entering or reaching into concrete mixing equipment accounted for 25% of the accidents involving concrete mixing and 3 of the 6 lockout/tagout related fatalities. Twelve percent of these accidents occurred when workers were attempting to access mixers. Fifteen percent of these accidents involved workers who were caught in or struck by chutes or hatches when they were not secured in place.

(b) Concrete Transport (0.8%)

Ready-mix concrete delivery trucks accounted for most of the accidents in this category. Usually the worker was struck by or caught between the delivery chute and the form. The more serious injuries happened during cleaning/maintenance operations on the trucks and were caused by lack of adequate energy control procedures.

(5) Casting Concrete (4.0%)

(a) Casting Concrete (3.1%)

The accidents that occurred during casting operations were most commonly caused by lack of access to the casting beds or between forms. Workers must continually get up onto and down from forms, or move back and forth between forms. In these instances, access was either not provided or was located in an area away from the work activity. Slipping or tripping on working surfaces caused almost 24% of the casting accidents. Most of the accidents were falls from or onto the casting bed, or involuntary recovery from slips or falls resulting in sprains, fractures, and contusions. Accidents that

were more task or tool specific (concrete delivery, pipe machine, scaffolds), yet still operationally part of the overall casting procedure, were included in the more specific category.

(b) Concrete Buckets (0.5%)

The injuries occurring to workers using concrete buckets were caused by the opening and closing mechanisms on the bucket's pour hatch. The latch bar frequently caught fingers and hands between the handle and the bucket.

(c) Pipe Manufacturing Equipment (0.4%)

The serious injuries to workers during mechanical pipe operations (packerhead and horizontal pipe spinning) were the result of inadequate machine guarding or isolation of the operation and the moving mechanical parts. A packerhead table with a gap between the table and the adjacent working surface caused a serious leg injury. Inadvertent entanglement with a horizontal pipe spinner injured another worker. Workers' eyes are also at risk in these operations. The rotating speeds used in these casting operations tend to "throw" cement and aggregate out into the adjacent work area.

(6) Sandblasting (0.3%)

The accidents that occurred during sandblasting operations were attributable to misuse of the sandblaster and/or the pressurized air system. Inadvertent activation of the sandblaster caused two of the reported accidents.

(7) Curing

Analysis of the accident reports failed to identify accidents which were specifically ascribed to the curing process. Factors which may influence the occurrence of accidents during curing procedures include contact with curing agents and hot steam, access to form and product, and cluttered or slick passageways, aisles, or other working/walking surfaces. These factors are discussed in the paragraphs on Chemical Handling in section a, and in the paragraphs on Personal Protective Equipment, Access, and Working/Walking Surfaces in section c.

(8) Product Handling and Transport (5.0%)

(a) Vehicles (3.4%)

This classification of equipment is comprised of various types of trucks (flatbeds, pickups) that are used to

transport products on or off of the plant premises. More than 82% of these accidents occurred while workers were attempting to get onto or off of the vehicle bed (access). The beds of these vehicles are typically 3 or more feet above the ground. Adequate foot and hand holds are seldom provided in places which would assist workers getting onto or off of the vehicles. Slippery or cluttered surfaces contributed to these accidents, resulting in all types of injuries (lacerations, fractures, contusions) to all parts of the body. Additionally, the SDS data (Table III-5) indicate that 1% of the injuries were sustained by occupants of motor vehicles involved in accidents. The SDS data also indicate that 2% of the injuries were attributed to workers falling off vehicles (see Table III-5, "Working/walking Surfaces").

(b) Product Removal (0.8%)

The most serious accident occurred when a crane was used to lift a product from a form to which the product remained adherent. When the crane attempted to hoist the product, the weight of the adhered form, an unknown force, resulted in crane overload and failure. One worker was killed.

Inadequate cribbing or blocking of the product during product removal tasks also resulted in serious injuries to workers (one was fatal). Workers under the product attempting to position rigging material or guide the load were injured when the product shifted, catching them under the load.

(c) Rolling Stock (Pipe) (0.8%)

Handling and storage of rolling stock (concrete pipe) resulted in 0.8% of the injuries in the industry. More than 55% of these accidents were the result of improper or nonexistent binding or chocking of the pipe. Although the back, hands and fingers were the most frequent parts of the body injured, the lower extremities were more seriously injured. Most of the remaining accident case histories cited rigging failure during stacking as the cause of the accident.

c. Accident Causal Factor Patterns

The method used to analyze the accident case histories allowed the identification of significant accident patterns by the grouping of related accident causal factors. For example, injuries attributed to wet, icy, or slippery surfaces; tripping; or puncture; are

discussed below under the general heading "Working/Walking Surfaces." These accident patterns indicate hazardous activities or conditions that encompass various tasks, industrial processes, tools, and items of equipment utilized in the precast concrete products industry. The arrangement of these patterns by percentage, in order from highest to lowest, is not intended to suggest that one accident pattern represents greater hazard to workers than another pattern, since data clarifying worker exposure are not available.

(1) Manual Materials Handling (17.6%)

There are two major accident types that occur as the result of improper manual materials handling procedures: overexertion accidents that cause sprains and strains of the back and shoulders, and materials movement accidents (dropped load, load placed on fingers) that usually result in lacerations, contusions, and fractures of fingers or toes. There is very little task specificity in manual materials handling accidents. Workers are required to lift and handle materials and tools throughout all precasting operations. They appear to be injured in proportion to the expected amount of manual materials handling likely to be used in any given task.

(2) Working/Walking Surfaces (12.4%)

The production processes of forming, pouring, stripping, and cleaning forms produce water, excess concrete, forming material, and a variety of tools and equipment that clutter walking and working surfaces. These hazards result in worker falls to the working surface and/or involuntary recovery injuries (sprains and strains that happen when a worker attempts to recover his balance). The SDS data (Table III-5) indicate that bodily motion (not including lifting, pushing or pulling) was the source of injury in 5% of the industry's accidents. Additionally, working surfaces were the source of injury in 12% of the accidents when workers fell while performing their duties.

Workers in form stripping operations (most likely responsible for exposed nails) are not the individuals usually injured by nails. The pattern of accidents related to nail puncture indicates that frequently (56%) it is a person walking through the area who steps on an exposed nail. Table III-5 indicates that nails were involved in 1% of all injuries, resulting most frequently in punctures to the foot.

(3) Personal Protective Equipment (10.7%)

The lack of personal protective equipment is not, in itself, a cause of accidents. However, during activities associated

with some tasks or tools, workers are exposed to hazards likely to result in injuries. For example, cutting torch tasks cause metal particles to fly through the air, increasing the probability of eye injuries; or, mixing and placement of concrete may result in material splashes that cause eye injuries; or, loads may fall or be dropped onto workers feet resulting in toe injuries.

In precasting operations, 10.7% of the injuries were likely to have been prevented by the employee wearing proper personal protective equipment. In most instances resulting in injury, the type of protective device found lacking was eye protective equipment. Concrete splashes, slag from cutting operations, metal particles from grinding, sawdust, particles falling from or blowing off forms, curing compounds, and general airborne dirt all resulted in eye injuries. Although safety glasses (eye protection) may not have prevented all of the reported injuries, their use certainly would have lowered the incidence of occupational eye injury.

Two fatal accidents in this category involved employees working from elevated areas and were directly attributable to the lack of fall protective devices. In both cases, the workers were performing tasks, on or from forms, without the protection of a safety belt and lanyard. The use of an adequate scaffold, including guardrails, would also have provided worker protection.

Crushing injuries to toes and feet resulting from the impact of heavy products and materials are not likely to be entirely eliminated by the wearing of safety-toed boots. However, such protective footwear would likely have prevented some of the injuries and reduced the severity of others in many of the cited instances.

(4) Access (9.8%)

Inadequate or nonexistent access to work areas was the primary causal factor in 9.8% of the accidents. As an accident causal factor, lack of adequate access resulted in workers being injured while performing most tasks and activities directly involved in the manufacture of precast concrete products. Workers attempting to move or work on casting beds and/or forms accounted for 38% of the "access" accidents. Most of these accidents were falls to lower levels; that is, off of the form or casting bed and onto the adjacent working surface (see Table III-5, "Working/walking surfaces"). Injuries ranged from simple bruises and lacerations to fractures. Many of the remaining "access" accidents were related to equipment; more than half of the vehicle access accidents involved

workers climbing onto or down from truck beds. Again, the injuries usually were caused by falls to below.

(5) Mechanical Materials Handling (7.6%)

Mechanical materials handling accidents comprised 38% (13) of the fatalities analyzed; half of these occurred to coworkers that were struck by a moving vehicle (crane, forklift). Twenty-three percent of the fatalities in mechanical materials handling were caused by rigging overloads. There were two incidents of crane "two-blocking" that resulted in fatal injury to workers.

The use of hoists, cranes, and forklifts is common throughout the industry. In many instances, the product is simply too heavy to move by other means. In some instances, the material is also too heavy to be moved by the selected mechanical method. Employees frequently work in close proximity to moving equipment. This interface, man and moving equipment, when compounded by the distractions of ongoing work and background noise, contributes to fatal accidents in precasting operations.

(6) Guarding (2.7%)

Inadequate or nonexistent guards were cited in 2.7% of the accidents. All but 2 of these 36 accidents occurred in conjunction with exposed moving parts of machinery and/or tools. Unguarded saws injured workers most frequently (31%), and unguarded grinders (abrasive stone) accounted for 17% of the injuries related to guarding.

(7) Chocking, Bracing, and Cribbing (2.6%)

The data indicate that most of the accidents that were caused by inadequate chocking, bracing, or cribbing occurred to employees engaged in tasks or activities related to partially assembled or dismantled forms. Form structures may adhere to concrete surfaces and then release suddenly. In some instances, employees were working (chipping, cleaning, welding, rigging) on or from forms that were braced or cribbed inadequately or not at all. Almost 12% of the fatal accidents in this industry occurred because of inadequate chocking or bracing.

(8) Lockout/Tagout (Control of Hazardous Energy) (1.6%)

Approximately 29% of the accidents caused by failure to control an energy source prior to performing maintenance or servicing activities were fatal. Inadequate control of hazardous energy resulted in 18% of the total fatalities.

Employees reaching or climbing into concrete mixing equipment (pan mixers, drum mixers, ready-mix trucks) without controlling the energy source accounted for three of the six fatal accidents.

Conveyors may jam during operation. Workers were injured while attempting to remove the jammed objects without first controlling the systems' energy sources.

D. New Employee Injury Rates

Analysis of the 1,319 accident case histories shows that 513 (54%) of the 950 reports that included length of employment information involved workers employed less than 1 year. In fact, 408 (43%) of the injuries were actually sustained by workers employed for less than 6 months.

Several factors may influence the apparent prevalence of injuries to new employees. Although some plants experience a relatively high turnover rate, many smaller plants seem to have a stable work force. These plants will layoff and rehire the same workers in accordance with seasonal or economic demands. Therefore, an injured employee reported as "new" on an injury report form, may actually be an experienced worker. Further, new employees may perform the more hazardous tasks. Or, new employees may typically comprise about 50% of the work force. No information which identifies either the distribution of tasks among workers of varying experience or the number of relatively new employees that make up the worker population at any given time is available. However, there is evidence to suggest that new employees or employees performing new tasks suffer significantly higher rates of injury than the employed population in general [25,26].

E. Summary of the Problem

Accident and injury statistics for 1980 indicate that the injury and illness incidence rate for the precast concrete products industry (SIC 3272) was 2.5 times the rate for all private sector industries. Not only does the precast concrete products industry have the problem of high injury incidence rates relative to all private sector industries, but within the manufacturing sector where there are similar tasks and operations, only 8, or 3.4%, of the 235 four-digit SIC code industries had higher incidence rates than this industry in 1980.

Analysis of 1,319 accident case histories has demonstrated how employees in the precast concrete products industry are injured while performing those tasks necessary to manufacture concrete products. Furthermore, patterns of accident causal factors common throughout the industry have been identified.

It is concluded that the primary safety needs of the precast concrete products industry are: 1) implementation of the recommendations for safe work practices presented in Chapter IV; and 2) implementation of a safety management program, such as the one presented in Chapter V.