<u>15th November 2018. Vol.96. No 21</u> © 2005 – ongoing JATIT & LLS

ISSN: 1992-8645

www.jatit.org



HYUN-JIN, YEO

Assistant Professor, Dongseo University, Division of Digital Contents, South Korea

E-mail: hjyeo@dongseo.ac.kr

ABSTRACT

The Korea has definite four seasons each having different temperature, humidity, and other weather factors. In that, the KMA(Korea Meteorological Administration) has been released diverse weather indexes from life style to industry weather indexes. However, indexes released by the KMA has rough numbers(indicators) which are not from data of industry when it comes to construction and other occupational injury related indexes. By the way, an occupational injury has been world widely studied to protect employees' life and labor power since an injury may cause death or partial disable. Especially, in construct area, an occupational injury is the most important concerns of construction companies. In this research, I merged weather data from KMA and occupational injury data from the KOSHA(Korea Occupational Safety and Health Agency) to make safety weather index with optimal scaling methodology. As a result, I made seven grade safety weather index which divided by injury type in construction industry.

Keywords: Occupational injury, Construction injury, Weather index, Safety weather

1. INTRODUCTION

1.1 Weather analysis

The Korea Meteorological Administration has been developed and released diverse weather related information not only common information such as temperature and humidity but also life indexes such as ultraviolet for outside activity, food poisoning, sensory temperature, laundry washing index, and other life related indexes [1]. Although those have not specific grades, 5 grades including low, normal, high, very high and danger, Koreans utilize those indexes as parameter of their lifestyle. Especially, today, the concentration of fine dust index becomes core index for outdoor activities such as running, picnic, and others.

Since the Korea Meteorological Administration (KMA) has released diverse and life practical indexes, diverse life familiar indexes have been continuously developed including convergence indexes meaning indexes for special purpose such as pollution index for factories and fine dust indexes for users who concerns air they breath and those who are mostly living in populated city such as the Seoul. Table 1 below shows lifestyle weather indexes those KMA release by website and smartphone application. Those index service supports open API that could facilitate diverse applicable services by not only government organizations but also weather information user

companies such as building construction companies and airline companies

E-ISSN: 1817-3195

Segment	Index
	Ultra Violet rays Index
	Food Poisoning Index
Life Weather Index	Heat Index
	Rotten Index
	Discomfort Index
	Wind Chill Index
	Freeze and Burst Index
	Frostbite Possibility Index
	Atmospheric Diffusion Index

TABLE 1: KMA LIFE WEATHER INDEX SERVICE

Although those indexes are statistically analyzed and released to public by the administration, there have been diverse needs to analyzed weather data and convergence research with other industry data [2]. The weather forecasting and current weather reporting is already widely used itself. For example, airport control tower utilize wind speed and direction, fog, typhoon location and others for airplane landing and take-off. There are strict regulation for airplane related to common weather factors. However, those are practices for weather information itself not convergence utility. <u>15th November 2018. Vol.96. No 21</u> © 2005 – ongoing JATIT & LLS

ISSN: 1992-8645

<u>www.jatit.org</u>



E-ISSN: 1817-3195

1.2 Occupational Injury and Construction

In 2016, an occupational injury and illnesses rate of the Korea is 0.49% and death rate is 0.96% when accidental death is 0.53% of them. meaning one of a hundred of employee is dead when he or she works [3]. In numbers, dead by accident employee is 969 which is 1.5% increase than prior year when number of accidental injury employee is 82,780 which is 0.7% increase [3]. The number looks not much for countries having more population then the Korea. However, the Korea has about 45million population and is aging society meaning work force is decreasing year by year. In that the Korea government efforts to decrease occupational injury and illness especially injuries those are much easier to manage than illness because illness is hard to control with system.

An occupational injury and illnesses are one of major concerns of government not only the Korean but also other major countries [4]. The United States has been managed nonfatal injuries and illnesses since 2003 and now, has 40 percent decreased TRC(Total Recordable Cases) [3][4]. Although the dramatic decrease happens on nonfatal injuries and illnesses area where healthcare and manufacturing industry causes most cases, the decreasing rate and speed is worthy of close attention when it comes to the England's high nonfatal and fatal injury and illness rate [5]. Whether it's fatal or non-fatal, an occupational injury and illnesses are hardly managed and monitored by government agency in each countries.

Although each country has own different economic and environmental condition which causes unique occupational injury management system, industries those causes injuries are similar: healthcare, construction and manufacturing. Figure 1 shows number of non-fatal occupational injury and illness employee in the Korea. In the graph except 'other industry' which means service industries such as health care, social welfare, cooking. and hotel, a manufacturing and construction injury and illness victims are dramatically higher than other industries even it's non-fatal. Unlike to the Korean, in the United States, construction industry has relatively lower than other industries [2][3].

Figure 2 shows a fatal occupational injury and illnesses in the Korea. Unlike to non-fatal, a construction, mining, and manufacturing industry is much more higher than others even than service industry (other industry in figure 2) [2][3]. Although the Korea has diverse industries, it still has labor oriented industry such as building construction as a major industry which causes frequent accident as one can see figure 2 because there are more manual labor workers in the industry [6].



Figure 1: Korean Non-Fatal Occupational Injury & Illness



Figure 2: Fatal Occupational Injury & Illness in the Korea

Because of the higher accident case of construction, mining, and manufacturing industry, the Korean research for occupational injury and illness focuses on those industries [7]. Figure 3 shows reasons of fatal occupational injury in the Korea that the most high rate in 'fall'. The figure illustrates purpose of this research because falling death happens barely in manufacturing or mining industry. In manufacturing and mining industry, they have less high attitude work environment than construction such as building.

Although there are high attitude facilities in manufacturing industry, accidents happens not to manufacturers but to constructors may works for manufacturing company or contracted construction company. Those accidents at figure 3 mostly happens outside working environments those are affected by weather conditions such as temperature, humidity and rain amount and snow. In this research, started with understanding above situations leads relationship between weather and construction worker's occupational injury. <u>15th November 2018. Vol.96. No 21</u> © 2005 – ongoing JATIT & LLS

ISSN: 1992-8645

www.jatit.org



E-ISSN: 1817-3195



Figure 3: Reasons of Fatal Occupational Injury

2. RELATED RESEARCHES

2.1 Weather Information for Industries

The Korea Meteorological Administration continuously release industrial weather indexes for five industries: agriculture, construction, energy, logistics and hightway at table 2 [2]. There are four indexes for construction area having the most many indexes with logistics area because those two industries' work safety relates to weather condition that lead detail indexes for them. Although those are developed by huge data of the administration, those indexes are not from convergence way, meaning it's from data of the administration itself but not joinning other administration or facilities' database such as the Ministry of employment and labor that we used for this research.

Industry	Index Name			
A	Agriculture Facility			
Agriculture	Pesticide Spray			
	Foundation Construction			
	Frame Construction			
Construction	Stone Construction			
	Finishing Construction			
Г	Heating Energy			
Energy	Cooling Energy			
	Fruits, Vegetables			
T	Sea Foods			
Logistics	Ice cream			
	Transport			
Highway	Highway			

TABLE 2: KMA INDUSTRIAL WEATHER INDEX

In that, especially for construction area, there are very rough grades as one can see at table 3. There are only three grades: bad, normal, and good for construction indexes. Below table 3 shows frame construction weather indexes and description. As one can see, each grade looks have specific numbers of guide, however, those are very similar to other outside activity index guide numbers such as indexes for outside leisure activities and also deales with only amount of rain and temperature.

Besides the weather indicators issue above paragraph, the KMA construction index has other limitation: type of injury. The index comes from type of construction such as frame, stone, finishing and foundation but not from types of injuries. That means, it is activity recommendation index rather than 'safety weather index'. As one can see at Figure 1 to 3, an occupational injury rate is differenciate by types of reason of injuries even it is fatal or non-fatal. Those graphs shows injuries should be analyzed by each, and also, wetather factor should be located on each injury type data rather than type of construction.

Types of construction in FMA indexes would not directly be related to occupational injuries because all types of injuries could be happened in every types of construction. For example, the injury cause 'fall' in construction industry, may happened all four: foundation, stone, finishing, and frame construction environments. The cause 'fall' does not depends on a type of construction but a type of work on injury day. Not only finising contruction has high height position work, but also other three could have. Furthermore, cause 'fall' may be happened in low height.

Grade	Weather Condition	Description
Bad	Over 5mm rain per day or minimum temperature under 0°C or maximum is over 30°C	Safe and process effectiveness is very low. Better to not work.
Vormal	Day rain amount under 5mm or daily average temperature over 5°C or under 17°C	Construction is possible

TABLE 3: FRAME CONSTRUCTION WEATHER INDEX

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Good	No rain and minimum temperature over 5°C and maximum is under 25°C	Good for construction
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Although indexes of KMA about construction is not suitable to prevent occupational injuries, KMA released open API(Application Program Interface) for weather raw data and open there weather data via website. The Korea Open Data Council(ODC) that supports and make regulations for opening public data released related law in 2013 [11]. The weather dataset which opened with open API is contactable to download with text format to put into any types of database that user utilize. Figure 4 shows sample dataset of KMA for wind speed. As one can see, it has observation spot number and wind speed data recored by every one hour. In this research, I utilize KMA past 5 years raw data about temperature, humidity, amount of rain, wind speed, and amout of snow.

SpotNum	Date	5 NUM	D, TEXT	10	WD_H01	WS_H01	WD, H02	W5, H02	WD_H03	WS, HOJ	WD_H04	WS, H04	WD_H05	W5,H05	WD_H06
- 90	2009-01-01	090	2009-01-01	090_2009-01	290	25	270	31	290	28	290	- 31	290	2.8	290
90	2009-01-03	090	2009-01-02	090,2009-05	290	43	290	35	290	3.7	290	43	290	43	290
90	2009-01-03	090	2009-01-03	090,2009-65	290	24	290	1.5	270	21	270	21	270	2.1	270
.90	2009-01-04	090	2009-01-04	090,2009-05	180	14	270	1	370	1 12	290	11	290	1.1	290
- 90	2009-01-05	090	2009-01-05	090,2009-03	320	23	27	1	320	15	320	15	290	1.1	290
90	2009-01-06	090	2009-01-06	090_2009-00	290	2.9	270	1.9	290	33	290	27	270	2.6	270
90	2009-01-03	1096	2009-01-07	090,2009-65	290	1	3.20	21	340	2.1	290	1	290	2.6	290
90	2009-01-08	090	2009-01-08	090_2009-01	290	21	3.20	11	340	3.7	290	22	320	- 1	120
- 90	2009-01-09	090	2009-01-09	090,2009-00	340	4	340	11	340	21	320	11	320	1	320
.90	2009-01-10	090	2009-01-10	090_2009-01	270	15	270	2	270	15	340	11	290	44	320
.90	2009-01-11	090	2009-01-11	090,2009-65	360	15	200	19	120	2.1	290	1.1	230	14	34
- 90	2009-01-13	090	2009-01-12	090,2009-05	200	1 11	250	2.1	230	1.5	380	1	290	3.0	250
	2009-01-1	090	2009-01-13	090,2009-05	320	1	270	1.1	290	14	270		270	15	27
- 90	2009-01-14	090	2009-01-14	090_2009-01	270	2.3	270	25	250	3.2	290	57	270	- 43	360
.90	2009-01-15	090	2009-01-15	090_2009-05	270	1.6	290	1 2	290	2.3	230	13	290	13	290
. 90	2009-01-16	090	2009-01-16	090,2009-03	364	1.7	290	11	3,20	- 1	290	1	270	4	- 2%
90	2009-01-17	090	2009-01-17	090,2009-00	160	1.1	250	16	370	13	290	25	290	14	200
	2009-01-18	090	2009-01-18	090,2009-00	250	13	29	- 24	230	1.7	250	1	290	1	34
90	2009-01-19	090	2009-01-19	090_2009-03	290	43	290	3.7	360	1 2	340	2.5	290	43	34
- 90	2009-01-20	090	2009-01-20	090_2009-65	. 270	1	170	13	340	1.6	270	11	200	0.5	34
90	2009-01-21	090	2009-01-21	090,2009-01	.200	11	290	2.8	270	1.1	270	1	230	0.5	230
. 90	2009-01-22	090	2009-01-22	090,2009-00	250	22	250	28	180	1	270	1/	270	16	10
90	2009-01-23	090	2009-01-23	090,2009-01	90	1.3	290	3.5	140	4.5	290		320	53	290
:90	2009-01-24	090	2009-01-24	090_2009-05	290	53	290	67	290	6.8	290		340	3.6	360
90	2009-01-29	090	2009-01-25	090_2009-00	340	1.6	290	19	3.20	1	380	0.7	230	1	290
- 00	2009-01-24	0990	2008-01-26	090 2008-01	- 292	-	360	21	140	2.2	141	24	290	21	290

Figure 4: KMA Sample Dataset of wind speed

2.2 Optimal Scaling

Gifi (1990) offers a comprehensive collection of nonlinear multivariate methods based on optimal scaling [12]. The start point of underlying analysis is a 0/1 dummy matrix which is based on the data considered as categorical. As a result, a loss function which involving the unknown object and category scores is established. During the iterations analyzer squeeze the variables and calculates category scores that they are optimal in the sense of a minimal loss function. These procedures are referred to as optimal scaling full range of parameters either [13]. There are two types of aspect for optimal scaling: Correlational and Non-Correlational aspect.

In correlational aspect and optimization, simple example is correaltion matrix meaning there are only two variables. The variation of the correlation coefficient by choise of category quatification [14]. In general case, there are multi variables not only two those lead diverse analysis forms: sum of correlations, sum of absolute correlations, eigenvalue aspect, determinal aspect, squared multiple correlations, and sum of squared multiple correlations [13]. In Non-correlational aspect, meaning linearizing regressions, the bilinearizability is core issue. Bilinearizability means that we can find transformations of the variables such that all bivariate regressions are exactly linear [13].

3. RESEARCH METHODOLOGY

3.1 Data Join and Cleansing

This study uses three years weather data since 2010 by the Korea Meteorological Administration (KMA) an hour diced and the same period occupational injury dataset from the Korea Occupational Safety and Health Agency (KOSHA). In order to join two different types of dataset setting primary key for database is core. The common and only factor of two different source dataset is region: the weather observation spot coordinates, and occupational injury accident spot in occupational injury report.

Before join two dataset, modification of regional data was necessary because the region data of KMA's is coordinate and KOSHA's is administrational address where the address regulation has been changed twice. Therefore, modifying regional data to match each of dataset is essential. In this research, I modified and matched them by four steps. First, I modified all old fashioned KOSHA's address data to new address regulation by text divide work with the Korean postal service address history data. Second, transform administrational address data at first step to coordinate data via weather spot address dataset of KMA. Third, calculate the nearest weather observation spot coordinate from occupational injury report address. Last, marked unique number according to coordinate data at each dataset. Figure 5 shows the process of primary key generation.

There are 107 missing (unknown) variables for the primary key generated because of fault of KOSHA dataset address which is irregular manual input data such as mistyping and not full address. Those 107 missing variables are manually filled. In this study we transfer spot number to minimum legal region size 'Dong' and mark post code for them. There are also multiple spots in same region because of height of instrument and other factors. Since purpose of this study is find out relation

<u>15th November 2018. Vol.96. No 21</u> © 2005 – ongoing JATIT & LLS

ISSN: 1992-8645

characteristic and purpose.

numeric for matching.

KMA Dataset

Coordinate and Ad

Observ Spot

Weather spot and Injury spot Mapp <u>www.jatit.org</u>

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multi-choice such as falling and slip, and some of them are not formal select input, but free text form.

Figure 6 shows informal dataset of injury data, and to standardize the dataset, decision of analysis purpose field is necessary. Since the purpose of this research is to make 'safety weather index', I clarify necessary fields such as time and type of injury.

POUND_LIMININGIND_NO	COMMERCIANI	IND_NM	IND_PCIND_ADDK_BACK
사업장설(지 노동 사업자변호	사업자명	사업장명	사업장፡사업장주소
61 6000	문우형	SX건설(주)	서울특별시 중로구 관훈동 192-18
20000701 51 7110 3010259257	김성수	신성상사	363922 충북 청원군 북이면
21 5000		동부건설(주)	인천광역시 중구 운서동 1512-64
20040201 84 4110 5061025250	전인배	이에스염	790370 경북 포랑시남구 제철동(숭내동)
2005323 85 3130		대우건설(주)의 1개사	
22 5110		굿모닝광고	경기도 수원시 영풍구 신동 600-4
22 5110		(주)휴면텍코리아	경기도 화성시 동탄면 청계리 65-19
12,2050		서인조경	서울시 강남구 역상동 683-18 솜씨빌딩 4중
19800601 92 4010 5148104557		아진제지공업(주)	711870 대구 달성 현풍 신기 92-1
22 5110		강원상사	경기도 평택시 포승면 희곡리 175-3
81 3010		대령산업(주)	동래구 온천동 1401-9
19870806 43 7210 3128104005	양준흥	다승	336912 충남 아산시 도고면 기곡리 174-13
20010801 63 6310 6168135924	조용철	동아육송주식회사	690150 제주 제주시 건입동
20030201 22 5110 1243088503	조현봉	서흥콘크리트	445941 경기 화성시 장안면 석포리
20030101 11 2040 1308147362	고등현	동일하이브	135090 서울 강남구 삼성동
22 5110 4108106267	이승기	삼농건설(주)	응인시 기홉읍 보라리 492번지 택지지구 78.4.
19820701 51 7110 3018104311	민훈기	다을제지	363920 충북 청원군 북이면 신대리 17-3
82 3150	김옥주	푸른조경	통영시 용남면 동달리 488
19820101 23 5140 1308114745	최덕순	한도철강(주)	425836 경기도 안산시 성곡동

				4	·	*	*					
GA SN	GALDATE	GA_WEACCOE	GA_AREA1	GA_AREA2	CA_AREA3	GAJAME	GA_FOST	64,500	GALGU	GA_0U_A00	64,911	
1123-72014	2010-07-10	90502	기파크사업	기타의학들사업	사람세비스럽	(平)利量相当	656881	39,92	카페시	경양님도_거래시	24	
20 10056-488	2010-03-21	22601	목조압	선복간조윗수락업	80055564	전월산업	656882	9882	카웨시	경상님도 거쳐시	294	
20 10063482	2010-05-09	60002	8.0	82	882	(平)年世	456862	5882	거레시	경영성도 거제시	294	
2010046848	2010-04-25	22601	제조업	선박진조용수곡합	200355è4	8396718	656906	5885	거제시	3885,74A	294	
2010074047	2010-07-14	90501	기타음사업	기타의각플사업		불리브레티킹	456714	5882	거해시	경망님도, 거격시	294	
2010034131	2010-03-11	40001	285	342	건축간설금사	서집청단독주락	656881	978E	거리시	경상님도, 거쳐시	294	
2010015552	2010-02-02	90501	기타용사용	기타위작물서업	842442	계동치인	436967	2058	21214	광양남동_거리시	254	
2010029075	2008-07-24	23601	125	44343+48	2023564.	상성충공입(守)	456710	2995	거제시	정말님도 거지지	294	
2010034299	2010-03-22	50901	*+-1218	828	428	12284	456813	29982	기계시	중앙날도_거쳐서	294	
20 3000 56 31	2010-03-06	33501	722	242222493	2023564	대부조선적합(中)	656714	2995	71781	경상날도 거쳐서	294	
20 2006 76 28	2015-07-06	22501	752	09222943	20225504.	대부조선적합(中)	656714	2995	거제시	경양날두_거지시	294	
20 200 385 35	2008-12-24	90504	기타의사업	기학의학물사업	개인했거식세비	지세요잡승가다	636882	27.46	거称시	2065,744	294	
2120054997	2010-05-11	40004	282	282	기타건물증식	거래시산동프랑	656934	2846	거제시	경망님도_거쳐서	294	
20 200 750 26	2010/07/27	23004	442	기타체호열	기하석중에트일	(약)거려분트믹	656905	2552	거래시	경상님도 거쳐서	214	
20 20 20 20 20 20 20 20 20 20 20 20 20 2	2010-03-13	23601	제조합	선택간조및수례법	80022264.	8922	656710	2995	거래시	경양님도 거쳐서	294	
2010096158	2010-32-01	+0001	282	282	040384	친려효(신축공사)	656230	2992	카페시	경양님트 거쳐시	294	
2110066913	2010-07-06	22601	적조업	선택한조뒷수려함	82022264	(平)世皇	656813	SARE	카페시	경양님도 거쳐시	294	
2110068099	2012-06-24	22601	목조업	선백건조용수락접	80025544	8조산업	655714	9888	거폐시	경양성도 거쳐시	294	
20 10057175	2010-06-17	90201	기타숙사업	유성및유사서비	위영및유사서비	거역시황황소급	456904	3992	거제시	경양성도 거쳐서	294	
20 100 770 92	2010-07-19	90501	기타의사업	기유의각출사업		HHRAD(8_	656790	398E	거제시	SWE ARA	294	
2010097960	2010-09-24	22601	제조업	04523048	\$2522Ee4	(型)过来	636713	5992	거리시	경영방도_거 져서	294	
2008095930	2008-08-29	22601	제품업	선복진조람수락왕	9003554.	대우준선배왕(주)	636714	5558	거제시	3945,784	294	

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Figure 6: Informal Dataset is cleaned and joined to formal

Since the weather measurement spot is not directly accurate to regional section of Korea, transfer measurement instrument spot to regional data is firstly performed. In this study we transfer spot number to minimum legal region size 'Dong' and mark post code for them.

There are also multiple spots in same region because of height of instrument and other factors. Since purpose of this study is find out relation between weather factors and industrial injury, we choose the closer spot to downtown or lower height. Final dataset consist of 518,208 records.

3.2 Correlation and Optimal Scaling

Weather factors utilized for this research are five: temperature, humidity, wind speed, rain amount, and snow amount. The correlation among weather factors and cause of injury factors are analyzed by Pearson correlation. Before correlation analysis, for the further study I tried multi logistic regression for causality analysis.

Figure 5: Dataset Join Primary Key Generation Process

between weather factors and occupational injury,

we choose the closer spot to downtown or lower

height. Those kind of works could not avoid manual works because observation spot has own

key generation without manual several works. The

process basically includes data format related

works such as transforming character field to

Postal Service Dat

KOSHA Dataset

Accident

Standard Address

The nearest

Figure 5 shows the brief process of primary

After mapping regional spot, time mapping is performed. The KMA weather dataset has separate date format field and text based hour term time field 'hour(numeric)+h(character)' and KOSHA dataset has one field having date and specific time. In that, the KOSHA time field should be divided to date and time that transformed to KMA format. Firstly, date and time is divided by simple database function 'left' and time is transformed by below rule. In the notation, t(m) stands for minutes of KMA format time while t(h) is hour. The final primary key made for this research is combination of spotnumber in figure 5 and h in below notation and final dataset consist of 197,382 records.

IF t(m) > 30 THEN h=t(h)+1 ELSE h=t(h) (1)

Although KMA weather data and KOSHA occupational injury dataset is joined, there are massive cleansing works remains especially for KOSHA dataset because KOSHA injury reporting system input interface has lots of informal factors meaning those are not standardized or have been changed. For example, some of injury cause has

IY E-ISSN: 1817-3195

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ISSN: 1992-8645	www.jatit.org	E-ISSN: 1817-3195

For correlation analysis with five weather factors and injury accident, target injury accident type is chosen by their frequency. In this research I choose three major accident: drop(15.1%), stuck(17.1%), and trip(18.7%). These three injury accidents are over 50% of occupational injury reason in construction industry and supposed to related to weather condition.

4. ANALYSIS RESULT

4.1 Basic data analysis

Table 4 show major frequency of accident from dataset I utilize for this research. Although there are diverse accident factors not listed on table 4 such as drawn, animal attack, violence, and suffocation, those are not analyzed because of their small sample size. In this research, I utilize top three portion accident type.

However, there are still diverse factors to be analyzed such as hit by object, cut, and bump. In occupational injury research, in fact, every accident type is important because those are directly or indirectly related to employee's life: life not only in terms of live or dead but also their remaining life because those kind of injury usually lead physical body disable.

TABLE 4: FREQUENCY OF MAJOR ACCIDENT TYPE IN	
CONSTRUCTION INDUSTRY	

Accident Type	Frequency	Portion
Inside Traffic accident	614	0.1%
Chemical Poison	2,056	0.4%
Explosion	2,078	0.4%
Fire	2,177	0.4%
Electric Shock	2,288	0.4%
Collapse	2,660	0.5%
Pin	14,154	2.7%
Outside traffic accident	22,691	4.4%
Work related disease	32,069	6.2%
Bump	40,232	7.8%
Cut	43,406	8.4%
Hit by object	44,311	8.6%
Drop	78,195	15,1%
Stuck	88,429	17.1%
Trip	96,761	18.7%

When it comes to monthly data, almost all months have trip as the highest rank except April,

May, and July. In those months, stuck accident type get the highest frequency rank those phenomenon could be told that there are weather factors. However, one can find in this research, there are not simple causality between weather factors and occupational injury meaning not there are no' causality but not 'simple' causality that I found in this research. There could be causality for further research such as pattern analysis and so on. Simple causality test shows at logistic regressions below.

4.2 Logistic Regression

In order to analyse causality, several logistic regression is performed. As a result there are not considerable direct causality between weather factors and occupational injury, but it is just simple analysis result for further studies not a purpose of this research. Table 5 shows binomial logistic regression result. In binomial logistic, dependent variable is accident happened or not.

1	-2log likelihood	Cox and snell R square	Nagelkerke R Square
Temp	3285968	.005	.011
Hmd	3285968	.005	.011
W.S	3290624	.005	.009
Rain	3313045	.000	.000
Snow	3313043	.000	.000

TABLE 5: BINOMIAL LOGISTIC REGRESSION

Besides the binomial logistic regression, multi logistic and other regression test shows there are not direct causal relationship between weather and accident. Table 6 shows R-square of multi logistic regression which also has very weak causality between weather and occupational accident. Above all negative result about casual relationships, however, it does only means weather factors directly causes occupational accident not means there are not any relationship between them. Related research also shows there are not simple direct causal relationship between them [17]. It does mean there are complex causal relation between weather and accident.

TABLE 6: MULTI LOGISTIC REGRESSION



<u>15th November 2018. Vol.96. No 21</u> © 2005 – ongoing JATIT & LLS

ISSN: 1992-8645

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E-ISSN: 1817-3195

Nagelkerke	.069
McFadden	.051

4.3 Optimal Scaling

Figure 7 shows result of optimal scaling for with seven degree for temperature, humidity, and wind speed those have enough observation numbers. Rain and snow amount has not seven degree because of observation frequency meaning in rainy and snow day, construction is usually stopped.





Figure 7: Optimal Scaling Result

As one can see at figure 7, for each weather factors, it has significant linear or non-linear trend line by scale. However, when it comes to the each accident divided dataset, the correlation result is different, meaning for each accident factor, there are different weather factors having correlation.

Table 7 shows weather factors having correlation for occupational accident type. Drop(Falling) has four weather factors having correlations, while trip and bump have three weather factors. Almost all accident type has not correlation to amount of snow weather factor. Although there could be diverse reason for snow amount exception, I expect in Korea, winter with snow day barely have construction work because of safety and other labor related issue such as labor law. Stuck type has only two weather factors having correlation: temperature and wind speed.

Table 7:	INJURIES	CORRELATION	WEATHER	FACTOR
Table 7:	INJURIES	CORRELATION	WEATHER	FACTO

Accident Type	Correlation Weather Factors		
Drop	Temperature, Humidity, Wind Speed, Rain		
Stuck	Temperature, Wind Speed		
Trip	Temperature, Humidity, Wind Speed		
Bump	Temperature, Humidity, Wind Speed		

Gra Inju	de and ryType	G1	G2	G3	G4	G5	G6	G7
s	Тетр							
T U C K	TEMP	-24.1~- 22	-21~55	5.6~ 11.8	119~ 17.7	178~ 240	24.1~ 31.7	318~ 375
	TEMP(Freq)	5,079	13,008	12,961	11,671	17,447	17,791	1,055
	InjuryRate	2.60%	250%	2.73%	260%	2.63%	293%	3.05%

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ISSN: 1992-8645

WS

WS(Freq)

InjuryRate

0-1.1

15299

2.16%

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7337

rate is affected. Secondly, causal relation analysis is simply performed because of this research main purpose: safety index. In that, in further research, more detail causality research could make significant result to prevent occupational injuries. On third, optimal scaling grade is targeted to seven, for detail and those specific target grade could lead different index result.

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5. CONCLUSION

frequency and accident rate.

In this research, whole three years weather dataset and occupational injury dataset is merged to analyze by coordinate of weather observation point and hour unit time. Five weather factors are utilized for analysis and representative three injury factors are also analyzed. Data cleaning and merging methodologies are complicate because of different data source and standard they have.

Wind Speed

16,761

305%

Table 8 shows sample safety weather index for stuck injury accident. For comfort, grades are

named G1 to G7, but numbers on grade does not

mean it's injury rate is higher or lower. In stuck

case, temperate G3, G6, and G7 has high accident

rate then others while wind speed G3,4 and 5 has.

However, when it comes to the frequency,

temperate grade 2, 5, and 6 has the highest injury

frequency. This index reflect construction work

frequency on those temperature. In Korea, those

temperatures are spring or autumn those season

have very high density of construction. In that,

application of index should be consider both

3.1~4.0

13239

3.09%

4.1~52

8.159

293%

53~23.6

5248

227%

-

-

-

12~21 22~30

20306

271%

In causal relation analysis, there are not simple significant causality found in this research. However, causal relation analysis is not for main purpose of this research and simply analyzed for future research. Through correlation analysis and optimal scaling, I found significant correlation between weather factors and injury accident reason, and through the optimal scaling for each injury type, this research suggests safety weather index for construction industry. Grades number in the index does not mean degree of injury warning rate and both frequency and injury rate for each grade should be considered for safety.

6. LIMITATION AND FUTURE RESEARCH

Although this research suggests methodology to make database based safety weather index, there are limitations and need further research. Firstly, the dataset in this research could not distinguish that there was a construction or not. That means injury





ISSN: 1992-8645

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