CENTRE FOR PUBLIC HEALTH RESEARCH

Exposure to silica dust in the construction industry in the Canterbury rebuild: A pilot study

A report for WorkSafe New Zealand

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Summary

Respirable crystalline silica (RCS) can cause silicosis and lung cancer and is also associated with chronic obstructive pulmonary disease (COPD), rheumatoid arthritis, scleroderma, Sjogren's syndrome, lupus and renal disease. Apart from a small pilot study on concrete drilling and cutting no other studies on RCS exposures have been conducted in the New Zealand construction industry. The current pilot study assessed: 1) personal respirable dust and RCS exposure levels in 39 construction workers involved in the Canterbury rebuild; and 2) the controls used to manage exposure. In addition, nine ambient air samples were collected. Sampling focussed on 'at risk' activities. Reported exposure levels are therefore not representative of all activities in the construction industry.

Twelve out of 39 personal dust samples (i.e. 31%) exceeded the NZ workplace exposure standard (WES) of 3 mg/m^3 for respirable dust. The majority of samples exceeding these limits were collected from concrete polishers and grinders with average respirable dust concentrations of 15.2 mg/m^3 and 13.8 mg/m^3 respectively. Drilling and Linea board cutting was also associated with higher dust levels with one in four samples exceeding NZ (and international) standards.

In total 14 out of 39 personal RCS samples (i.e. 36%) exceeded the NZ WES of 200 µg/m^3, 16 (41%) exceeded the UK Health and Safety Executive workplace exposure limit (HSE WEL) of 100 µg/m^3, and 22 (56%) exceeded the American Conference of Industrial Hygienists threshold limit value (ACGIH TLV) of 25 µg/m^3. The highest levels were observed in concrete polishers and grinders with average concentrations of 306 µg/m^3 and 657µg/m^3 respectively. Although exposure levels associated with other tasks (bobcat and digger driving, jackhammering, cutting concrete, drilling, labouring, crushing, and cutting Linea board) were lower, they still regularly exceeded the ACGIH TLV of 25 µg/m^3. None of the nine static RCS samples exceeded the NZ and HSE standards, but two of the four samples collected close to Linea board cutting exceeded the ACGIH TLV.

Observations by subcontracted field staff suggested that a large number of construction workers were not using respiratory protection. Those who did were unaware of the need for it to be fit tested and the need to be clean shaven for it to be optimally effective. Large polishing equipment was fitted with vacuum systems, but smaller (hand-held) grinding and polishing equipment was used without dust extraction. Concrete cutting was conducted using a wet cutting system.

In conclusion, this pilot study showed that workers performing selected 'at risk' tasks in the construction industry in New Zealand are being exposed to levels of respirable dust and RCS exceeding national and international standards. Preliminary data suggest that control measures currently applied may not be adequate to protect workers from adverse respiratory effects. The results of this study together with extensive data from international studies, therefore suggest that action is required to reduce silica exposure in the New Zealand construction industry.

Introduction

Despite the construction industry being the sixth biggest industry sector in New Zealand, employing 8.1% (180,000) of the total workforce, relatively little research has been conducted here to assess hazardous exposures and health risks in this industry. Thus, to date, most information regarding exposure levels and associated health risks is based on overseas data.

The Canterbury rebuild involves large-scale demolition, reconstruction and renovation/repair of residential, commercial and civil construction. This type of work has the potential to place a large number of workers at risk of being exposed to respirable crystalline silica (RCS), particularly given the large scale demolition of concrete structures.

RCS has a long history of causing silicosis (Leung et al., 2012), a type of pneumoconiosis marked by progressive fibrosis or scarring of the lung tissue with loss of lung function leading to shortness of breath, severe cough and weakness. In 1997 the International Agency for Research on Cancer IARC classified RCS as a human carcinogen after assessing the epidemiological evidence that silica exposed workers were also at risk of developing lung cancer (IARC, 1997). More recently, RCS has also been associated with other conditions including pulmonary tuberculosis, chronic obstructive pulmonary disease (COPD), rheumatoid arthritis, scleroderma, Sjogren's syndrome, lupus and renal disease (Möhner et al., 2013, Steenland 2005, Parks et al., 1999). Exposure to respirable dust (apart from RCS) is also a known risk factor for asthma and COPD (Douwes et al., 2014) which are both common occupational conditions in New Zealand and internationally.

As a consequence, stringent work exposure standards have been adopted internationally. In New Zealand the current Workplace Exposure Standard (WES) for RCS has remained at 200 $\mu g/m^3$ for the last 20 years and has therefore not taken into account recent epidemiological evidence showing significant risk of lung cancer at levels well below this WES. The UK Health and Safety Executive (HSE) applies a workplace exposure limit of 100 $\mu g/m^3$, and international exposure limits which have been updated more recently are even lower. For example, the American Conference of Governmental Industrial Hygienists (ACGIH) recommends a threshold limit value (TLV) for respirable quartz of 25 $\mu g/m^3$ and OSHA recently proposed a new rule for RCS of 50 $\mu g/m^3$.

Several small studies in New Zealand have assessed occupational RCS exposures in workers involved in sand or abrasive blasting (NZ Dept of Health 1982-a), foundry work (NZ Dept of Health 1982-b), road sealing operations (NZ Dept of Health 1984), mining, quarry work, lime works, tunnelling and gold testing (Glass et al., 2003). A significant proportion of samples reported in these studies exceeded the current New Zealand WES. For example, a Department of Labour survey conducted in the period 1995-1999 that targeted high risk working situations showed that 13% of 87 samples exceeded the WES for RCS of 200 µg/m^3. A recent pilot study on concrete drilling and cutting compared the difference in silica dust levels between dry and wet work methods (Chung and Glass, 2013). This study indicated that personal respirable silica levels were all below the current New Zealand WES of 200 µg/m^3 but above the ACGIH TLV of 25 µg/m^3. It also showed that wet methods of dust control were more effective than dry methods reducing inhalable dust exposure by more than 90%. No other RCS exposure data for the New Zealand construction industry is available.

Research questions and aims

This pilot study sought to answer the following questions:

1. What are current personal respirable dust and RCS exposure levels in construction workers involved in the Canterbury rebuild?
2. What controls are in place to manage exposure?

The aims of the pilot study were:

1. To assess personal respirable dust and RCS exposure levels in construction workers involved in the Canterbury rebuild with a focus on those job titles/tasks with expected high exposures;
2. To assess (in a small sample) static respirable dust and RCS concentrations in close proximity to construction activities;
3. To compare exposure levels with national and international limits;
4. To provide a preliminary indication of what exposure controls are in place;
5. To provide WorkSafe with provisional conclusions and recommendations (based on aims 1-4) on potential health risks.

The pilot study is based on the collection of a limited number of personal (n=39) and static (n=9) airborne respirable dust samples. Sampling focussed on what was regarded as the more 'at risk' activities i.e. the worst case scenario. Exposure levels in this report are therefore not representative of all activities in the construction industry.

Methods

Participant recruitment, sampling, laboratory analyses and assessment of exposure sources and controls were subcontracted to and conducted by K2 Environmental Ltd.

Participant recruitment

K2 Environmental Ltd approached a large number of firms, but only a few agreed to participate. Most tasks were measured in workers employed by larger firms which used purpose built vacuum systems to reduce dust exposures.

Tasks monitored

The following tasks were monitored: bobcat and digger drivers, jackhammering, concrete cutting, polishing and grinding, and drilling, crushing cutting Linea board, and general labouring. For a detailed description and photographic details of several of the tasks monitored, the reader is referred to a report prepared K2 Environmental Ltd (Huffadine and Keer-Keer, 2015).

Respirable dust monitoring

Dust samples were taken according to: AS2985 -2009 Workplace atmospheres – Method for sampling and gravimetric determination of respirable dust. Briefly, samples were taken at an airflow of 2.2 l/min using Higgins Dewell cyclones (Casella) and 25mm PVC filters. A total of 39 personal samples and nine static samples were collected. Of the 39 personal samples, 33 were taken over a period of four or more hours. Of the nine static samples all but one took place over four or more hours.

Gravimetric measurements

Gravimetric measurements were conducted by K2 Environmental Ltd using a Sartorius balance with a resolution of 0.01 mg. Six samples had dust weights below the detection limit. For samples below the limit of detection we assigned a dust concentration of 0.01 mg/m^3 i.e. half of the lowest observed concentration in this study.

Laboratory analyses

Crystalline silica was analysed on the filter using X ray diffraction (XRD) (according to the NIOSH 7500 standard) by AEC Environmental in Australia. The limit of detection for crystalline silica was 5µg. When filters were overloaded analyses were conducted as if samples were solid powders rather than dust on filters. Seven samples were not analysed for crystalline silica due to very low dust weights. For those samples the concentration was assumed to be 1.05 µg/m^3 i.e. half of the lowest observed concentration in this study.

Assessment of exposure sources and controls applied by workers and industry

Sources of exposure and the use of exposure controls were observed (qualitatively) by K2 Environmental Ltd field staff.

Data analyses

Descriptive statistics including geometric mean respirable and RCS exposure levels stratified by work task were calculated. Geometric means (GM) and geometric standard deviations (GSD) are presented because most exposure data are log-normally distributed and in those cases arithmetic means (AMs) and standard deviations (SDs) may overestimate the true mean. Also, the use of GMs and GSDs allow direct comparisons to be made with the international literature which for the same reason do not report AMs and SDs. Median levels and minimum and maximum levels are also presented if more than two samples per task were available. The proportion of samples above the NZ WES, the HSE WEL and ACGIH TLV were also identified.

Results

In total 39 personal samples and 9 static samples were available for gravimetric analyses. Five samples (representing general labouring tasks (n=3), drilling (n=2), jack hammering (n=1), and digging (n=1)) were not analysed for RCS as dust levels were very low and in those cases it was assumed that RCS levels were half of the lowest observed concentration in this study i.e. 1.05 μg/m^3 (see methods section). Individual measurements of respirable dust and RSC levels are reported in Appendix 1. Mean levels stratified by task and proportion of samples exceeding NZ and international standards for respirable dust and RCS are described below. For a detailed description and photographic details of several of the tasks monitored, the reader is referred to a report prepared K2 Environmental Ltd (Huffadine and Keer-Keer, 2015).

<u>Respirable dust</u>

Twelve out of 39 personal dust samples (i.e. 31%) exceeded the NZ WES, HSE WEL and ACGIH TLV of 3 mg/m^3 for respirable dust. The majority of samples exceeding these limits were collected from concrete polishers and concrete grinders (Table 1). The average dust concentrations for concrete polishing and grinding were 4.2 mg/m^3 and 5.5 mg/m^3 respectively; however, there was substantial variance in dust levels as indicated by the relatively high standard deviations. Drilling and Linea board cutting was also associated with higher dust levels with one in four samples exceeding NZ and international standards (Table 1).

Table 1: Personal respirable dust levels

Task	N	GM (GSD) mg/m^3	Median (min-max) mg/m^3	>NZ WES, HSE WEL, ACGIH TLV i.e. 3mg/m^3
Bobcat/digger driving	5	0.4 (8.3)	0.8 (0.0-2.0)	0 (0%)
Jackhammering	2	0.0 (6.8)	-	0 (0%)
Concrete cutting	1	0.7 (-)	-	0 (0%)
Concrete polishing	5	4.2 (10.5)	13.3 (0.15-47.4)	3 (60%)
Concrete grinding	10	5.5 (6.9)	11.2 (0.1-39.6)	7 (70%)
Drilling	4	0.1 (17.7)*	0.02 (0.0-3.8)*	1 (25%)
Labouring	5	0.1 (10.8)*	0.0 (0.0-2.2)*	0 (0%)
Crushing	3	0.4 (3.7)	0.6 (0.1-1.3)	0 (0%)
Linea board cutting	4	0.3 (9.3)*	0.2 (0.0-5.8)*	1 (25%)

N = number of samples; GM (GSD) = Geometric mean with geometric standard deviation.
* Non-detectable samples were included and the concentration of these samples was assumed to be 0.01mg/m^3.

None of the nine static dust samples exceeded the NZ and international standards including those collected close to concrete polishing and grinding (Table 2). Ambient dust levels were generally considerably lower than personal dust levels.

Table 2: Static respirable dust levels

Task	N	GM (GSD) mg/m^3	Median (min-max) mg/m^3	>NZ WES, HSE WEL, ACGIH TLV i.e. 3 mg/m^3
Concrete polishing	2	0.1 (2.7)	-	0 (0%)
Concrete grinding	3	0.2 (12.5)*	0.1 (0.0-2.6)*	0 (0%)
Linea board cutting	4	0.3 (6.0)	0.5 (0.1-1.7)	0 (0%)

N = number of samples; GM (GSD) = Geometric mean with geometric standard deviation.
* Non-detectable samples were included and the concentration of these samples was assumed to be 0.01mg/m^3.

Respirable crystalline silica

In total 14 out of 39 personal RCS samples (i.e. 36%) exceeded the NZ WES of 200 µg/m^3, 16 (41%) exceeded the HSE WEL of 100 µg/m^3, and 22 (56%) exceeded the ACGIH TLV of 25 µg/m^3. The highest levels of RCS were observed in concrete polishers and grinders with average concentrations of 306 µg/m^3 and 657 µg/m^3 respectively (Table 3). As with respirable dust concentrations, there was considerable variance around the mean as indicated by the high standard deviations. For all tasks tested we found at least one sample to exceed the ACGIH TLV. Quartz content of sampled dust based on a weight ratio was approximately 10% and ranged from 6% to 18% depending on the specific task that was measured (Table 3).

Table 3: Personal respirable crystalline silica levels

Task	N	GM (GSD) µg/m^{3†}	Median (min-max) µg/m^{3†}	%qz	>NZ WES 200 µg/m^{3†}	>HSE WEL 100 µg/m^{3†}	>ACGIH TLV 25 µg/m^{3†}
Bobcat/digger	5	8.7 (8.0)	2.9 (1.1-143)	6%	0 (0%)	0 (0%)	2 (40%)
Jackhammering	2	6.2 (12.4)	-	18%	0 (0%)	0 (0%)	1 (50%)
Concr cutting	1	100 (-)	-	15%	0 (0%)	1 (100%)	1 (100%)
Concr polishing	5	305.6 (21.3)	1765 (3.2-4767)	9%	3 (60%)	3 (60%)	4 (80%)
Concr grinding	10	657.1 (5.4)	1127.5 (12.3-3207)	15%	8 (80%)	9 (90%)	9 (90%)
Drilling	4	7.0 (23.7)*	1.9 (1.05-762)*	14%	1 (25%)	1 (25%)	1 (25%)
Labouring	5	3.9 (10.2)*	1.05 (1.05-222)*	7%	1 (20%)	1 (20%)	1 (20%)
Crushing	3	25.6 (4.7)	52.8 (4.3-73.8)	6%	0 (0%)	0 (0%)	2 (67%)
Linea board cut	4	16.6 (11.2)	11.1 (2.1-486)	6%	1 (25%)	1 (25%)	1 (25%)

N = number of samples; GM (GSD) = Geometric mean with geometric standard deviation; %qz = quartz/dust ratio*100%; * Non-detectable samples were included and the concentration of these samples was assumed to be 1.05 µg/m^3. † 1 µg equals 0.001 mg.

None of the nine static RCS samples exceeded the NZ and HSE standards, but two of the four samples collected close to Linea board cutting exceeded the ACGIH TLV (Table 4). As is usually the case ambient RCS levels were generally considerably lower than personal RCS levels, which suggests that bystanders are generally at significantly lower risk from these dust emissions. Quartz content of ambient dust samples was similar to that observed for personal samples and equated to approximately 9% and ranged from 6% to 11% depending on the specific task that was measured (Table 4).

Table 4: Static respirable crystalline silica levels

Task	N	GM (GSD) μg/m^3	Median (min-max) μg/m3	%qz	>NZ WES 200 μg/m^{3†}	>HSE WEL 100 μg/m^{3†}	>ACGIH TLV 25 μg/m^{3†}
Concr polishing	2	2.7 (1.7)	-	6%	0 (0%)	0 (0%)	0 (0%)
Concr grinding	3	2.4 (4.1)	1.1 (1.1-12.1)	8%	0 (0%)	0 (0%)	0 (0%)
Linea board cut	4	9.8 (5.1)	14.4 (2.1-59.6)	11%	0 (0%)	0 (0%)	2 (50%)

N = number of samples; GM (GSD) = Geometric mean with geometric standard deviation; %qz = quartz/dust ratio*100%; † 1 μg equals 0.001 mg.

Use of exposure control measures

Observations by K2 Environmental Ltd field staff suggested that a large number of construction workers were not using respiratory protection. Those who did were unaware of the need for it to be fit tested and the need to be clean shaven for it to be optimally effective. Several of the workers monitored did use respiratory protection, but not always in an effective manner. In particular, several digger drivers used filter cartridge respirators but they did not wear them inside the enclosed cabs; a worker cutting concrete who wore no respirator had a shield which covered his face, but this was lifted up as it quickly got covered in slurry; polishers and grinders were wearing filter cartridge respirators which had not been fit tested and several were not clean shaven; workers involved in drilling, labouring and crushing did not use respirators. Generally, most workers lacked knowledge regarding the correct wearing, storage and maintenance of respirators.

Large polishing equipment used vacuum systems, but smaller (hand-held) grinding and polishing equipment was used without dust extraction. Concrete cutting was conducted using a wet cutting system, but no system was in place to deal with slurry at the work place and on workers' cloths.

Other observations

Workers appeared to be unaware of the health risks of silica exposure. Also, many construction workers are smokers which may add to the risk of silica exposure causing adverse health effects (Tse et al., 2014).

Discussion and conclusions

Silicosis and/or lung cancer caused by occupational RCS is largely preventable provided airborne exposures can be minimised and/or workers are adequately protected from inhaling RCS. At this stage it is not clear what typical RCS exposure levels in the New Zealand construction industry are and how well exposure control strategies are being applied. This information is required to assess potential health risks of the 180,000 workers employed in this industry, and for strategies to be developed to reduce exposure and minimise potential risks.

The results of this small pilot study have shown that RCS and respirable dust exposures measured in a limited number of 'high risk' tasks regularly exceed New Zealand and international standards. Qualitative observations by field staff also suggest that exposure control options and the use of personal protective equipment are underutilised and/or applied inadequately. Given that this was a small study involving a limited number of workers mostly employed by a small number of larger companies which use purpose built vacuum systems to reduce dust exposures, and specifically selected 'high risk' tasks it is unclear whether the results are representative of the industry at large.

In this report we have compared measured RCS levels with the New Zealand WES of 200 µg/m^3, however, the current New Zealand WES has not been updated for at least 20 years and has, as a consequence, not taken into account the current literature showing significant health effects at levels well below this standard. We therefore consider it more appropriate to compare results with the ACGIH TLV for RCS of 25 µg/m^3 which appropriately takes into account these more recent findings.

This pilot study found that 56% of the personal samples exceeded the ACGIH TLV. This is consistent with international studies which also show that workers in the construction industry are regularly over exposed to RCS. For example, a recent study in Alberta, Canada found that 77% of workers in new construction (n=44), 40% of workers in demolition (n=10) and 57% of workers involved in abrasive blasting (n=26) were exposed to RCS levels exceeding 25 µg/m^3 (Radnoff et al., 2014). A study in the Netherlands in construction workers (n=149) showed that 62% of personal RSC samples exceeded the Dutch occupational exposure limit of 75µg/m^3 (Deurssen et al., 2014). A recent literature-based exposure database summarising silica exposure measurements (n=2,858) collected in the construction industry from 1990 to 2013 and published in the international literature, also confirmed that over-exposure to RCS is common in this industry (Beaudry et al., 2013). In particular, the study reported geometric mean RCS levels of 1590 µg/m^3 for abrasive blasting, 700 µg/m^3 for masonry cutting, 560 µg/m^3 for concrete grinding, 410 µg/m^3 for breaking/jack hammering concrete and 390 µg/m^3 for cutting tunnels. RCS levels measured in the pilot study are therefore comparable (particularly for concrete polishing and grinding) to those reported for the construction industry in other countries.

Taken together, these studies strongly suggest that RCS exposures in construction workers are widespread and often exceed international standards. The levels of respirable dust in the construction industry reported in the scientific literature also often exceed the international standard of 3 mg/m^3 (e.g. Deurssen et al., 2014) and the results of this pilot study are consistent with this, i.e. 31% of personal samples exceeded this limit. The large proportion of samples exceeding national and international standards for both respirable dust and RCS are of concern given exposure to these agents are known to cause serious health effects (see introduction).

The pilot study showed that local exhaust ventilation or dust extraction was often not applied particularly when using hand held tools. Also, a large number of construction workers were not using respiratory protection. Where respiratory protection was used it was not always applied according to best practice. To reduce exposure levels and minimise risk there is a strong need for improved exposure control strategies and more effective use of personal protective equipment. Work activities are highly dynamic and diverse and exposure control strategies in the construction industry are therefore challenging. Nonetheless, several field studies have shown significantly reduced RCS exposures associated with local dust extraction on equipment including hand-held devices, use of on-tool shrouds, use of appropriately ventilated cabs, and wet dust suppression (Rappaport et al., 2003; Akbar-Khanzadeh et al., 2001; Healy et al., 2014) suggesting that interventions are feasible and effective. However, as noted by Rappaport et al, (2003) "*while engineering and administrative interventions are needed to reduce overall air levels, the heterogeneous exposure among members of each trade suggest that controls should focus, in part, upon the individual sites, activities and equipment involved*". In other words, a "one size fits all" approach may not be effective and interventions would need to be tailored for specific groups within the building industry.

Conclusions

This small pilot study showed that workers performing selected 'at risk' tasks in the construction industry in New Zealand are being exposed to levels of respirable dust and RCS exceeding national and international standards. Preliminary data suggest that control measures currently applied in the building industry may not be adequate to protect workers from adverse respiratory effects. The results of this study, together with extensive data from international studies, therefore suggests that urgent action is required to reduce respirable dust and silica exposure in the New Zealand construction industry thereby minimising the risk of adverse health effects of the 180,000 workers employed in this industry.

Recommendations

Based on the results of this pilot study and the international literature on respirable dust and RCS exposures in the construction industry more generally we have the following recommendations:

- That WorkSafe urgently reviews the current WES for respirable silica of 200 $\mu g/m^3$ to bring it in line with more recently updated international standards such as the ACGIH TLV of 25 $\mu g/m^3$.
- That WorkSafe develop user-friendly guidance material on the health risks of silica and methods of reducing exposure, using both printed material and video, for its own staff as well as for the workforce.
- That WorkSafe require all industry where silica exposure is likely, to establish a systematic assessment programme to define exposure profiles, determine the risk, introduce adequate control and respiratory protection measures and maintain ongoing environmental and biological surveillance procedures.
- That Worksafe consider the establishment of a silica exposure register similar to the asbestos exposure register.

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Appendix 1: Individual dust and quartz concentrations

Task	Type of sample	Time in minutes	Volume in m^3	Dust in mg/m^3	Quartz in $\mu g/m^3$	% quartz
bobcat	personal	455	1.12	2	143	7.2
digger	personal	445	1.09	0.38	41.3	10.9
digger	personal	460	1.14	0.01	1.05	10.5
digger	personal	362	0.91	0.8	2.8	0.4
digger	personal	358	0.86	1.18	2.9	0.2
jackhammer	personal	107	0.27	0.01	1.05	10.5
jackhammer	personal	320	0.81	0.15	37	24.7
cutting	personal	275	0.69	0.69	100	14.5
polishing	personal	318	0.79	0.15	3.2	2.1
polishing	personal	73	0.18	0.94	55.1	5.9
polishing	personal	302	0.76	13.3	1765	13.3
polishing	personal	349	0.86	14.4	1796	12.5
polishing	personal	427	1.05	47.4	4767	10.1
Grinding	personal	328	0.81	0.1	12.3	12.3
Grinding	personal	240	0.57	1.25	149	11.9
Grinding	personal	350	0.83	5.8	542	9.3
Grinding	personal	103	0.26	23.8	2283	9.6
Grinding	personal	389	1.01	0.7	396	56.6
Grinding	personal	382	1	12.1	1205	10.0
Grinding	personal	383	0.94	16.7	1387	8.3
Grinding	personal	380	0.94	39.6	3207	8.1
Grinding	personal	345	0.84	27.7	2969	10.7
Grinding	personal	300	0.76	10.3	1050	10.2
drilling	personal	198	0.49	0.01	1.05	10.5
drilling	personal	332	0.85	0.01	1.05	10.5
drilling	personal	360	0.89	0.02	2.8	14.0
drilling	personal	90	0.22	3.81	762	20.0
Labouring	personal	76	0.19	0.01	1.05	10.5
Labouring	personal	297	0.76	0.03	1.05	3.5
Labouring	personal	293	0.71	0.35	3.5	1.0
Labouring	personal	377	0.9	0.01	1.05	10.5
Labouring	personal	55	0.14	2.15	222	10.3
crushing	personal	358	0.88	1.27	73.8	5.8
crushing	personal	462	1.14	0.62	52.8	8.5
crushing	personal	464	1.16	0.1	4.3	4.3
Linea board cutting	personal	400	0.99	5.8	486	8.4
Linea board cutting	personal	240	0.59	0.07	4.2	6.0
Linea board cutting	personal	339	0.84	0.31	17.9	5.8
Linea board cutting	personal	477	1.17	0.04	2.1	5.3
polishing	static	308	0.76	0.16	6.6	4.1

polishing	static	314	0.8	0.04	3.1	7.8
Grinding	static	357	0.9	0.02	1.05	5.3
Grinding	static	322	0.82	0.07	12.1	17.3
Grinding	static	9	0.02	2.6	1.05	0.0
Linea board cutting	static	397	0.97	0.07	25.8	36.9
Linea board cutting	static	240	0.59	1.74	59.6	3.4
Linea board cutting	static	339	0.86	0.93	2.9	0.3
Linea board cutting	static	478	1.21	0.05	2.1	4.2