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GOVERNMENTAL DUST CONTROL IN CONSTRUCTION INDUSTRY: A STUDY OF POLICIES

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Abstract: Construction dust emission has become an outstanding issue in the construction industry. As a key content of green construction, governments around the world have the responsibility of mitigating the adverse effects of dust emission on the environment. However, little has been known of how governments can sharpen their efforts in this area. Using literature survey and content analysis, this study aims to identify the main roles of governments in construction dust control. Considerable policies were collected for analysis. It is found that governments have three characters in the dust control, namely opinion leaders, policy makers and technical supporters. As policy makers, governmental measures for dust emission control span widely, which include technology, economy, management and organizational governance. The results shed some lights on the measurement of governmental policies in the dust control.

1 INTRODUCTION

The construction industry plays a vital role in a socio-economic entity. However, it has become the targets of environmentalists and sociologists. One of the main reasons is that the construction industry has become a key consumer of energy and a major pollutant of the physical environment (Wallis 2012,Wang 2014). Basically, construction activities including land excavation, concrete construction, demolition activities, roadwork and building decoration generate a great deal of environmental pollution such as dust, noise, garbage and solid waste (Shenet al. 2010). Of all these pollutants, dust emission poses considerable threats on human health and local environments and it has attracted closer attention in recent years (Bergdahl et al. 2004)

Dust emission on construction sites enforces frontline workers and local people more vulnerable to suffer from clinical health problems or other potentially longer-term health problems (Steenlandet al. 2001). Silica dust, wood dust, demolition dust and other construction dust involving gypsum, limestone, marble and dolomite are the four main types of construction dust on construction sites (Partanenet al. 1995). There is widespread concern about the over exposure of construction workers to respirable crystalline silica, which is a major constituent of dust emission (Flanagan et al. 2010). Previous studies suggested that approximately 60% workers employed in the construction industry were possibly exposed to silica in 2009 in Netherlands (Lumens and Spee 2001), and the exposure levels of silica exceed occupational exposure limits (OELs) in works such as drilling, blasting, screening, grinding, crushing and earth-moving which involve silica-containing material or equipment that creates particles (Nijet al. 2003).

Construction dust has also been found as a main reason for severe diseases including silicosis, bronchitis, obstruction of trachea, occupational asthma as well as the decline in pulmonary function (Chisholm 1999). As revealed in a cohort mortality study of industrial sand workers, there is a causal relationship between lung cancer and crystalline silica exposure (Nget al. 1987,Steenland et al. 2001). Other hazard substances of construction dust like wood dust and demolition dust also presenting a risk of disease such as occupational asthma and Chronic Obstructive Pulmonary Disease (COPD). COPD is predominantly caused by smoking; however exposure to harmful dusts can also bring on the onset of COPD even if the person does not smoke (Bergdahl et al. 2004).

Particulate matter, also known as PM, is a complex mixture of extremely small particles and liquid droplets including acids, organic chemicals, metals, and soil or dust particles (Zhao et al. 2006). As for the environmental impact, growing size of construction activities have enhanced the level of PM10 and PM2.5 (particulate matter with aerodynamic diameters less than 10 um and 2.5 um) in cities. Researchers have found that high death rates of asthma, heart disease, and other ailments are attributed to all PM components (Lumens and Spee 2001,Zhang 2006). Major cities in the world such as London, New Delhi and Mexico and many cities in China have suffered from high levels of particulate pollution over the past two decades. In fact, a series of environmental impacts caused by construction activities have been worse off. Early in 1989, in appreciating account energy efficiency and emission reduction, the Chartered Institute of Building report (CIB 1989) identified four areas for improving environmental management on construction sites - (i) Efficient use of energy and natural resources;(ii) Carefully selecting environmentally friendly building materials and the control of toxic chemicals and dangerous wastes; (iii) Pollution control, clean technologies, recycling and waste management, and (iv) Environmental education via intensive training. In line with these principles, fugitive dust, as a major source of pollutants emission on construction site, is due to bear responsibilities for all negative influences.

Detailed planning and effective construction management are necessary to reduce the adverse impact of dust emission on the surrounding environment, the current mayor of London pointed out (Johnson.2014). As a key member of social regulator, governmental authorities ought to review and assess the situation of dust emission in the territory. This is the same case in many developing countries. In China, governmental efforts to control dust emission are gradually unfolded (Tanget al. 2013, Ye et al. 2013). Nowadays, governments worldwide are attempting to make due response to this challenge. However, what is the role of governments in this domain? How can they do effectively? Such questions have not yet been addressed clearly. Therefore, this study aims to investigate governmental policies on construction dust control with the intention of answering these two questions.

2 REASERCH METHODS

The main method adopted in the study is literature review and content analysis. The research starts with identifying the roles of governments in the practices of construction dust control. Progress in promulgating dust control policies has been made worldwide including Asia, North America, and Europe. Relevant polices and regulatory documents of these regions were collected for analysis and comparison. As one of the largest developing countries, China is still in an important period of strategic opportunities for construction and will build at such an unprecedented speed and scale. Finally, the case of China was adopted analyze governmental measures introduced in surveyed policies.

3 ROLE OF GOVERNMENT IN CONSTRUCTION DUST CONTROL

Government plays a key role in practicing construction dust control. As the main point of green construction, fugitive dust controlling need for governmental intervention especially in the early stage. The limitation of people's rational recognition and self-consciousness combined with the failed formation of evaluation criterion and behavioral patterns backed up by common goals further at this stage underline the necessity of making effective activities though correct induction of government. The effectiveness of construction dust control depends on a systematic program that involves a number of main bodies including governmental authorities at various levels and relevant parties like the owner, construction and supervision organization. As the owners of public works, governmental authorities bear responsibilities of

reducing dust emissions of their own projects; On the other hand, they play a role as social regulators in monitoring dust emissions in the local construction industry. While stakeholders in construction are largely profit-oriented, the actions taken by governments should be driven by a desire to improve social and environmental benefits. Institution-related drivers for government to improve both social and environmental benefits include affecting the behavior of individuals and firms, providing institutional guarantee and supporting and promoting technological innovation (Fraser 2013, Sharratt and Auvermann 2014).

3.1 Opinion Leaders

Prior to the formation of public willingness to pay for environmental protection, inducing and promoting practices for construction dust by affecting the behavior of individuals and firms is necessary. Individuals maximize temporary advantages, which is short-signed, while companies respond to costs and profits, which are their primary drivers (Witzke and Urfei 2001, Franzen and Vogl 2013). However, in construction, whether each stakeholder acknowledges and accepts the idea of environmentally friendly “Dust-free” and then makes it a lasting habit is more essential. Therefore, the great importance of government’s propaganda and guidance becomes to emerge; they pose a direct impact on public recognition and awareness and then form an industrial development pattern featuring the interaction between governments and enterprises (Wang and Ye 2010). American was the ultimate practitioner of this role, popularizing preventive and treatment knowledge of construction dust with the united efforts of Occupational Safety and Health Administration (OSHA) and Non-government organization (NGOs).

3.2 Policy Makers

The most fundamental function of government is to provide institution guarantee for various social undertakings, achieved by means of rules and regulations. As mentioned above, practices of construction dust monitoring place responsibility on all stakeholders; it is harder to correctly identify responsibilities of each stakeholders and that explains why regulatory gaps and overlapping responsibilities are most likely to occur. The governmental function of instituting policy support and improving supervisory mechanisms is necessary in this sense. In many countries, law of environmental protection, as the foundation law, stated the requirements of taking necessary measures to monitor dust emission. However, the most specific regulations were mostly promulgated by local governments of city or county level. Providing tools and practical guidance according to the general policies issued by central governments, local governments actually play a dual role.

3.3 Technical Supporters

Dust control needs technical support. Practices for suppressing dust emission in construction are quite miscellaneous but can be classified into several distinct categories, including suppression by water infusion or wet cutting methods, dilution by ventilation system, mitigation by water sprays and scrubbers, and isolation by personal respiratory (Nijet al. 2003). In the process of renovation which is difficult for dry sweeping, studies suggested the use of a central vacuum system as a control measure for construction renovation sites (Lehtinen et al. 1996). Commonly used infrastructures like vacuum cleaner, local exhaust system (LEV) and windbreaks hedge are developed by firms, whilst they must bear all risk and pressure during the process of technological innovation. It is government who provide a strong backstop for stimulating and supporting innovations through actions including providing basic infrastructures and platforms for communication, collaboration, and knowledge sharing (Patanakul and Pinto 2014).

Table 1: List of policies/ Regulatory documents on construction dust control

Country	State/ County/ City	Year	Policy/Regulatory documents	Authorities	Requirements	Resources
U.K	/	1984	the Building Act 1984	The Secretary of State	Placed conditions on the demolition notice to ensure the effective dust management.	http://www.legislation.gov.uk/ukpga/1984/55
U.K	/	2002	Control of Substances Hazardous to Health Regulations	Health and Safety Executive	Specify the maximum level of Respirable Crystalline Silica (RCS) that workers can suffer (Working Exposure Level).	http://www.hse.gov.uk/coshh/
U.S	/	2013	OSHA's Proposed Crystalline Silica Rule: Construction	Occupational Safety and Health Administration	Measure the amount of silica that workers are exposed to; Provide respirators and medical exam to workers	https://www.osha.gov/silica/factsheets/OSHA_FS3681_Silica_Construction.v2.html
Ireland	/	2013	Safety, Health and Welfare at Work (Construction) Regulations 2013	Health and Safety Authority	Contractor shall ensure that appropriate steps are taken to suppress (water sprays or other means) any dust generated during the process of demolition.	http://www.hsa.ie/eng/Legislation/New_Legislation/SI_291_2013.pdf
U.S	Nevada/ Clark	2004	Policy on Dust Control Permit Design and Posting of Signage	Clark County Department of Air Quality	Explain license application and emission targets/permits that are adopted for construction sites in its administrative area.	http://www.clarkcountynv.gov/Depts/AirQuality/Documents/DustControl/DustForms/Sign.pdf
U.K	London	2014	The Control Of Dust And Emissions During Construction And Demolition SPG	the Greater London Authority and London Councils	The developers shall provide an Air Quality and Dust Risk Assessment including the confirmation of both dust emission control	https://www.london.gov.uk/sites/default/files/Dust%20and%20Emissions%20SPG%208%20July%202014_0.pdf

Table 1 (Continued): List of policies/ Regulatory documents on construction dust control

Country	State/ County/ City	Year	Policy/Regulatory documents	Authorities	Requirements	Resources
U.K	Buckingha mshire County/ Aylesbury Vale	2010	Construction Site Dust Management Guidance	Environment al Health Division: Aylesbury Vale District Council	If mobile concrete crushing or screening plant is present on site, the Land and Air Quality Team shall be notified in order to undertake a site visit and liaise with operator of plant.	http://www.ayl esburyvaledc. gov.uk/GetAss et.aspx?id=fA AxADIAMwAz ADcAfAB8AF QAcgB1AGUA fAB8ADAAfAA 1 U.S
U.S	Wisconsin	N/A	Dust Control on Construction Sites Conservation Practice Standard	Wisconsin Department of Natural Resources	Asphalt and petroleum based products cannot be used for dust control; Dry applied polymers must be initially watered for activation to be effective.	http://dnr.wi.go v/topic/stormw ater/document s/DustControl _1068.pdf

4 POLICIES TO MONITOR CONSTRUCTION DUST EMISSION

4.1 A Review on Relevant Policies

As policy makers, governments are responsible for provide institutional guarantee for suppressing on-site dust t. The policy and supervising framework that support the construction dust management served well in many regions of the world. It has gradually sustained massive decrease of construction dust contamination especially silica-oriented cases and, in doing so, has accelerate the global process of sustainable construction in parallel. America, whose policy system of dust monitoring is more developed comparatively, is exampled. Since relevant policies, rules are mostly formulated by local authorities of states, counties, districts and boroughs in the U.S, they varies evidently and present diversification as well. Taking Yakima Washington for example, the policy "Construction Dust Control Policy of the Yakima Regional Clean Air Agency", which was promulgated in August 9, 2012, aims to reduce fugitive dust emissions with an emphasis on prevention rather than mitigation (Pruitt 2012). And Clark county focus on license application and emission targets instead of specific control measures, which makes on-site managers feel easy to further strength their supervision and inspection on dust discharge through quantitative evaluation. In addition, other governmental agencies like OSHA and Health and Safety Executive(HSE)in U.K also take their efforts. This paper provides a review on these policies promulgated by various authorities. The policy data gained from the relevant sources are mainly about laws and regulations, administrative rules and governmental plan. And these sources are approached by visiting the official websites, as see the Table 1 for more information.

4.2 Governmental Measures for Construction Dust Control in China

Nationwide the legal demand for improvements in emission control of construction dust in China have been tightened severely in the past decades (Pilarczyket al. 2013). In practice, however, the legalization started lately and it did not gained inadequate attention at that time. Until the year 2000, the Chinese

government promulgated the third version of “Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution”. In this law, a dust-free view is addressed, and then firstly added contents related to construction dust monitoring (mentioned in paragraph 2 of article 43). Pattern of “Central coordination, local implementation” on monitoring construction dust is thus laid in China. Subsequently, in 2004, the ministry of construction issued a series of standards on construction site including some compulsory rules that shall be strictly enforced like enclosure construction and road hardening. After that, local governments have commenced to promote dust controlling practices, more practical standards and specifications were elaborated.

Capital cities function as centers of politics, economy, military and culture in different regions. By investigating related policies of 32capital cities in mainland China, it showed that 26 cities including Beijing, Hangzhou and Shanghai have launched special scheme of prevention of dust pollution on construction site. More specific information about these regulations is described in Table 2.

Table 2: Information of first special scheme on construction dust in 26 cities

City	Promulgation date	Reference number
Peking	1999/9/14	Order of the people's government of Beijing (No.37)
Hangzhou	2002/4/13	Hang Zheng Ban [2002] No.24
Shanghai	2003/8/8	Hu Jian Jian [2003] No.504
Tianjin	2004/2/16	Jian Zhu [2004] No.149
Shijiazhuang	2004/12/30	Order of the people's government of Shijiazhuang (No.140)
Changsha	2005/10/11	Chang Jian Fa [2005] No.2
Chengdu	2006/7/7	Cheng Fang Fa [2006] No.56
Chongqing	2009/1/19	Yu Jian Fa [2009] No.13

Table 2 (Continued) Information of first special scheme on construction dust in 26 cities

City	Promulgation date	Reference number
Ningbo	2010/11/25	Yong Zheng Ban Fa [2010] No.238
Shaoxing	2011/2/19	Shao Shi Jian Guan [2011] No.19
Guangzhou	2011/7/22	Shui Jian Zhi [2011] No.773
Weinan	2011/11/23	Wei Zheng Ban Fa [2011] No.109
Zhengzhou	2012/2/8	Zheng Zheng [2012] No.6
Nanking	2012/4/18	Ning Jian Zhi Zi [2012] No.381
Fuzhou	2012/6/27	Rong Jian An [2012] No.25
Nanchang	2012/12/24	Hong Fu Ting Fa [2012] No.139
Xi’an	2013/1/9	Shi Jian Fa [2013] No.10
Jinan	2013/11/18	Ji Da Qi [2013] No.5
Hefei*	2013/12/20	He Jian [2013] No. 156
Taiyuan	2014/2/20	N/A
Lanzhou	2014/2/22	Lan Cheng Chen ZhiZi [2014] No.1
Haikou	2014/3/4	N/A
Huhehot	2014/4/2	Hu Zheng Fa [2013] No. 34
Xiamen	2014/5/29	Min Jian Jian [2014] No.21
Shenyang	2014/2/26	Shen Jian Fa [2014] No.34

Using the method of content analysis, measures included in those policies (including 26 policies issued by governments of city level and standards mentioned before) above were extracted. The primary mission of content analysis is to make inferences by objectively and systematically identifying specified characteristics of messages (Holsti 1969). In current study, two steps under this method were followed, namely (i) identifying “construction dust” per regulatory document; (ii) identifying related dust control methods involved per regulatory document. By eliminating contents which are general, superficial and

untargeted, and then consolidating provisions that are similar, 30 measures were recognized as described in Table 3.

Table 3: Construction dust measures in 26 cities

Categories	Measures	
Technology (TE)	TE1: Enclosure construction; TE2: Vehicle washing TE3: Sedimentation tank TE4: Ground surface hardening / greening / covering TE5: Rational material stacking or storage TE6: Prohibition of waste incineration TE7: Prohibition of high altitude throwing	TE8:Prohibition of field concrete and mortar TE9:Restricting construction during high winds TE10: Wet work TE11: Dust collecting system TE12: Windbreaks hedge TE13: Sprinkles
Economy (EC)	EC1: Administrative sanction EC2: Budgeted overhead expenses	EC3: Levying charges for disposing dust pollutants EC4: Special funds control
Supervision (SU)	SU1: Mass media supervision SU2: Video monitor	SU3: Complaints from the mass SU4: The third-party supervision
Organization (OR)	OR1: Dust proof bureau/Steering group OR2: Establish joint conference system	OR3: Education and training
Assessment (AS)	AS1: Civilized construction unit competition AS2: Taking dust control into political achievement system AS3: Taking dust control into credit system of building market	AS4: Taking dust control into EIA (environmental impact assessment) AS5: Being linked to qualification and irregularities of construction companies AS6: Being linked to irregularities of clients

Since these measures seem quite different from each other, they can be divided into five important aspects:

- TECHNOLOGY—Measures directly taken by construction enterprises on site (13 measures);
- ECONOMY—Instruments to steer stakeholders' behaviours by using economic factors influential to the cost-effective (4 measures);
- SUPERVISION—Methods by which various subjects monitor stakeholders to standardize their behaviours during the process of following the legal requirements (4 measures);
- ORGANIZATION—Measures that are conducted to analyze organizational factors in the process of dust management in order to establish the internal accountability system and improve management and operation mechanism (3 measures);
- ASSESSMENT—Measures acting as an instrument to restrict and regulate the activity of individuals, enterprises even governments by making their performance being linked to related evaluation system (6 measures);

5 CONCLUDING REMARKS

The successful control of construction dust has been highly concerned in the domain of green construction. Server air pollution combined with more potential health hazards caused by construction fugitive dust has triggered the governmental alarm. Governments, as owner of public works, should endeavour to reduce dust emissions of their own projects; and have more responsibilities as leaders and supporters of sustainable strategy. In this study, three main role of government played in practices of construction dust management were recognized and analyzed. As policy makers, it is found that governments around the globe should make due response to provide institutional guarantee. By taking China as example, it is found that specific governmental measures suitable to control dust emission varies from one sector to another, including technology, economy, organization, supervision to assessment, which provides guidelines for other countries to formulate policies. However, which

measures governments are more interested in and what measures are major and effective have not explored explicitly. The research findings can pave some ways for future studies on effectiveness of governmental policies on construction dust control.

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