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DEBRIS MANAGEMENT AND RESTORATION OF THE MIYAGI PREFECTURE AFTER THE 2011 TOHOKU EARTHQUAKE AND TSUNAMI

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Abstract

The 2011 Great East Japan (Tohoku) Earthquake and Tsunami had a very devastating effect on the coastal townships, industrial fishing and farming communities. An overwhelming amount of debris was generated in the three damaged prefectures (Iwate, Miyagi and Fukushima). The earthquake and tsunami debris quantities exceeded 27 million tons, with the Miyagi prefecture having the largest amount of 18.73 million tons. This generated debris included construction/building rubble, vegetative debris, vehicles, vessels and tsunami deposits. Management of the debris proved difficult due to the variant types and large quantities, requiring the need for multiple debris operation sites for sorting and disposal. This case study reviews the progress in debris management within the first four years of the planned 10 year recovery period. The discussion includes: site allocation for debris processing, debris collection and sorting procedures, debris storage, and reconstruction planning of debris operation sites. The Miyagi prefecture completed its debris operations within the first three years, the restoration phase of the recovery. The reconstruction phase is currently underway. Concrete debris and tsunami deposits have been recycled for use within the reconstruction projects. The findings of this case study will be used in a future comparative study of disaster debris management in Japan over time.

Keywords: tsunami; recovery; debris processing; management; reconstruction

1. Introduction

Each year, society is threatened by a potential for hazards resulting in economical and environmentally-damaging impacts. These impacts range anywhere from a category five hurricane to the collapse of a major earthquake. Generated debris is a “highly visible reminder” of the extent of a disaster, and its removal accounts for as much as 40% of all disaster-related costs [1]. On March 11, 2011 the Tohoku region of Japan was struck by a violent 9.0 magnitude earthquake and generated tsunami. Over 350,000 buildings were fully or partially collapsed causing an estimated $210 billion in economic damage [2, 3]. As a result of this disaster, Japan had the daunting task of managing over 27 million tons of debris. Miyagi, Iwate and Fukushima prefectures experienced the greatest amount of damage with debris quantities estimated at 18.73 million tons, 5.25 million tons and 3.61 million tons, respectively [4, 5]. Fig. 1 presents the three affected prefectures.

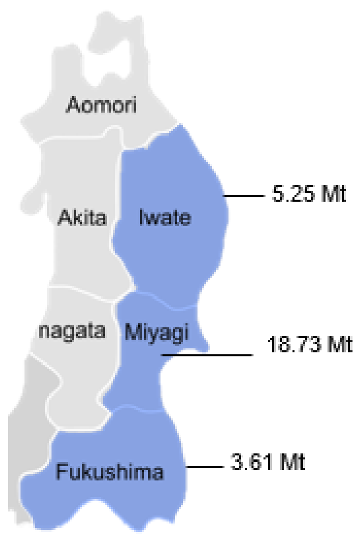

Fig. 1: Three prefectures within the Tohoku region affected by the 3/11 disaster and the estimated debris quantities (estimation by Ministry of the Environment [6]). Mt = million tons.

Managing large amounts of debris like that accumulated in the Miyagi prefecture can be a very taxing expenditure, both in time and money. Debris generated by a tsunami can be difficult to manage as it is mixed with various types of rubble and waste. The mix may include large volumes of construction/demolition waste, marine sediments, shipping vessels, vehicles, vegetation, salt water, plastics and sludge [2, 7]. Therefore, effective management processes and procedures are key for a recovery process. As shown in other disasters the way in which debris is handled can impact the overall recovery duration. In 2005 Hurricane Katrina caused over $80 billion worth of damage and generated 22 mil tons of debris (excluding demolition). It took the city of New Orleans more than five years to deal with all the rubble and waste [8, 9]. The 2011 Joplin Tornado (EF5) destroyed over 8,000 buildings and generated 4.2 mil tons (3 mil CY) of debris, having an estimated damage of $2.8 billion [10]. With the Expedited Debris Removal (EDR) initiative the city of Joplin was able to clear the area of debris within 3.5 months [11]. In terms of debris, the Joplin Tornado is one-fifth the size of Hurricane Katrina and the Tohoku tsunami.

Debris management can be broken up into a three phase process. The initial phase should begin with the removal of debris for site access, aiding in the efforts of emergency response and recuse. This is followed by the restoration phase, where the focus is on re-establishing the lifelines and the debris is sorted and processed.

Finally, during the reconstruction phase the processed debris can be used for reconstruction. This paper will focus on debris operations for the Miyagi prefecture. A review of the sorting procedures used as well as the plans for reconstruction will be presented.

2. Miyagi Debris Management

The recovery process in Tohoku, Japan is projected to take up to 10 years to complete. Fig. 2 provides the projected timeline for the disaster restoration and reconstruction work. The processing the disaster debris began in early 2012, while the processing of the tsunami deposits did not began until 2013 [4]. With a goal of completion of March 2014, this put the total time for debris management at two years. The processing period for the disaster debris was completed within the three year restoration period. The initial management of debris was handled by local municipality hired construction companies. The debris was transported first to a primary collection site. Contractors hired by the prefectural government then moved the debris to a secondary collection site for processing and disposal [3].

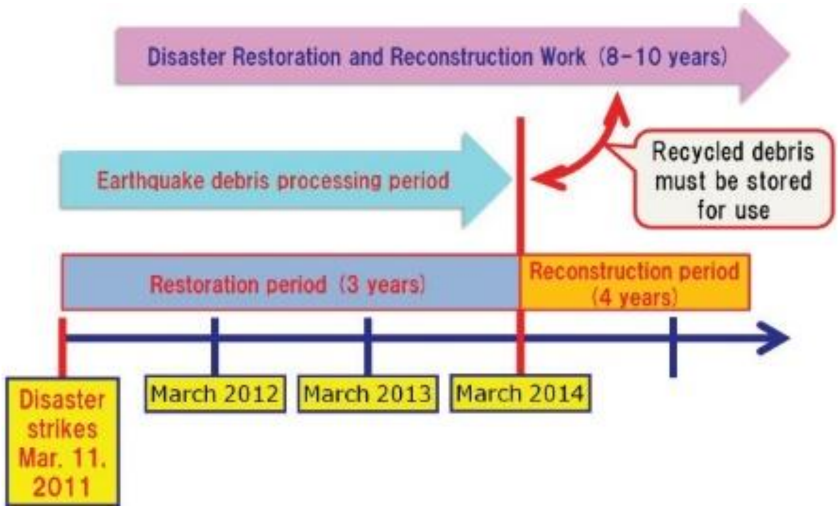

Fig. 2: Timeline for effective use of disaster debris generated by the 2011 Great East Japan Earthquake and Tsunami [4].

The initial expectation was to process and dispose over 900,000 tons of the debris from the Miyagi prefecture [3]. To aid the management process, the east coast of Miyagi was divided into four areas: Kesennuma area, Ishinomaki area, Sendai city and Natori area.

Within the first six months following the disaster, the Miyagi east block (Shiogama city, Shichigahama town, Tagajou city) had treated more than 50% of its debris and tsunami deposits [12]. At the onset, the speed of the waste treatment was not sufficient. The combustible and non-combustible debris required accelerated treatment. Thus the number of temporary incinerators was increased and cooperation agreements were made for debris processing in non-affected areas. In addition, public buildings were demolished to accelerate the production of recycled materials [13].

2.1 Debris Processing

Of the 300 temporary storage sites utilized to deal with the disaster debris and tsunami deposits, 100 were located within the Miyagi prefecture. In the prefecture 29 temporary incinerators (+4 additional in normal operation) were operated for combustible waste, while 12 shredding and sorting facilities were used for non-combustible waste [12]. Examples of the processing facilities are presented in Fig. 3 and Fig. 4. The debris separation process is outlined in Fig. 5. Separation is conducted not only at the removal or temporary storage site but also at the preliminary storage site.

Fig. 3: Temporary incinerator in Kesennuma City, Miyagi [12].

Fig.4: Debris Operation site in Ishinomaki, Miyagi [3].

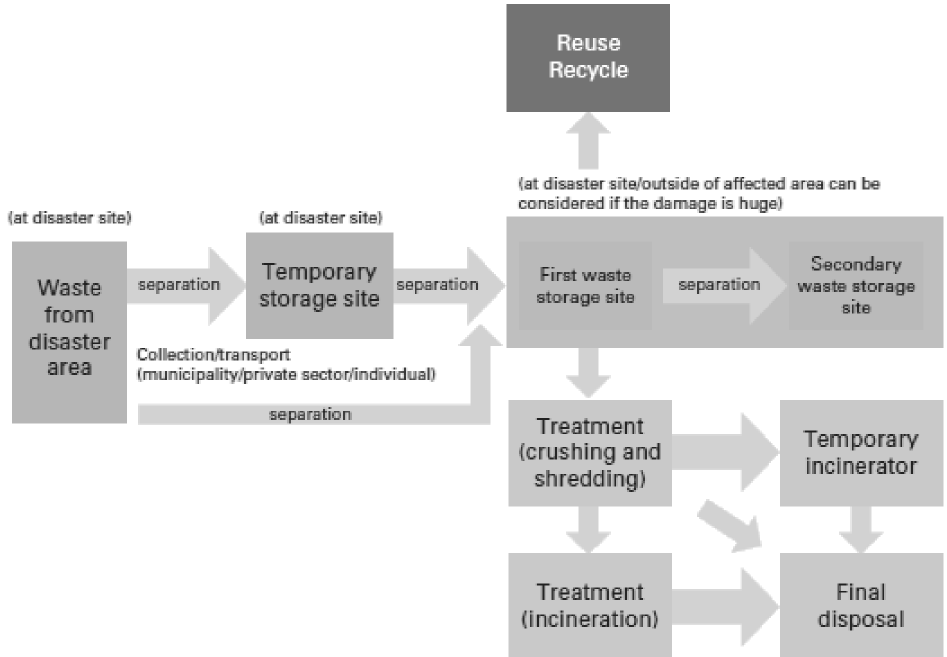

Fig. 5: Outline of the processes for separation and disposal of disaster waste [14, 15].

Sendai city's advanced action in separating the debris waste was used as a model for other affected cities. Debris was processed quickly because of the large number of workers in specialized teams and the advantage of city information and transportation networks. In its expansive waste site on the Sendai Plain, the debris was sorted into six categories: concrete, vegetative/wood, white goods/appliances, metal, tires, hazardous goods (MOE 2011, Hisada et. al 2015). Figs. 6, 7, 8 and 9 display the temporary sorting sites. However, in some areas, securing land for the temporary storage site was a challenge. Much of the Tohoku region affected by the disaster is comprised of coastal area, where the immediate need was temporary housing [16].

Fig. 6: Sorting of white good/appliances waste in Ishinomaki, Miyagi Prefecture (photo by T. Norton June 2011).

Fig. 7: Temporary storage site of debris in Ishinomaki City, Miyagi Prefecture (photo by T. Norton June 2011).

Fig. 8: Temporary storage of damaged vehicles in Minami-Sanriku, Miyagi Prefecture (photo by T. Norton June 2011).

Fig. 9: Temporary storage of concrete rubble in Natori, Miyagi Prefecture (photo by T. Norton June 2011).

Under a cooperative agreement, non-affected prefectures assisted in the disposal of combustible and wood waste. Recipient prefectures of Miyagi waste include: Aomori, Yamagata, Fukushima, Ibaraki, Tochigi, Tokyo and Fukuoka.

2.2 Debris Recycling

At the time of a disaster, planners must determine the quantity of waste generated, gather it in temporary storage sites, and select and arrange for appropriate disposal or recycling options [14]. The potential to recycle or reuse the debris is sometimes overlooked in order to clear affected areas quickly. Commonly, the debris is dumped in overloaded landfills which can be costly, both economically and environmentally [17, 18]. However with large quantities, like that generated in Tohoku, it will be difficult to use a landfill for disposal, therefore it is vital to recycle as much as possible [7].

Japan has been influential in advancing the best practices for handling disaster debris. The Japan Society of Material Cycles and Waste Management (JSMCWM) suggest that recycling should be considered in the management of debris as it helps to put resources to use in the recovery and reconstruction process. In its recommendations concrete debris is recycled for rebuilding, wood scraps can substitute for fossil fuels in power generation, scrap metal is recycled and tires are shredded to crumbs and recycled or incinerated [15]. The Debris Management Guide published by FEMA includes similar recommendations. It suggests that the recycling of waste could not only aid in the reconstruction efforts, but it has the potential to speed up the recovery process [19].

85% of the recycled concrete debris and tsunami deposits are planned for use within public works projects. These projects include the restoration of coastal embankments, disaster prevention forests and national parks. They started in late fall 2012 with embankment restoration in Natori city and national park restoration in Kesennuma city [13]. Table 1 presents the public works projects planned for the Miyagi prefecture.

Table 1 - Major public works projects using materials recycled from debris and tsunami deposits [6].

	Project	Recycled Material	Amount (including planned use)
Miyagi Prefecture	Coastal or river embankment restoration	Tsunami deposits Concrete debris	103
	Coastal disaster-prevention forest restoration	Tsunami deposits Concrete debris	110
	Agricultural field restoration	Tsunami deposits	15
	Park construction	Tsunami deposits Concrete debris	262
	Fishing port projects	Concrete debris	29
	Construction of temporary storage sites	Tsunami deposits Concrete debris	89
	Other projects	Tsunami deposits Concrete debris	114

New technologies were needed for the reuse of contaminated concrete rubble as it would not meet the Japanese Industrial Standards (JIS) requirements for recycled aggregate. Several entities, including construction companies, universities and local government, collaborated on the development of these new technologies or recycle/reuse procedures. The results include: wave dissipating blocks filled with concrete debris, roller compacted road base made from concrete and tsunami sediment, soil stabilizing material and molded blocks as base material for levee surge barrier [4].

3. Reconstruction Efforts

The Tohoku region, specifically the Miyagi, Iwate and Fukushima prefectures, will not return to the way it was before the disaster but instead will be a more hazard resilient "New Tohoku". Fig. 10 provides a glance at the planned recovery. The region will be rebuilt using innovative ideas that also address challenges related to the aging population in rural and coastal communities and the relocation of younger citizens to urban cities [20]. The New Tohoku supports accelerated construction projects for housing. Approximately 21,000 new housing is planned for new land developments that have be relocated inland or to higher ground. Another 30,000 public housing is planned for the disaster-affected areas [21]. A sample reconstruction model is provided in Fig. 11.

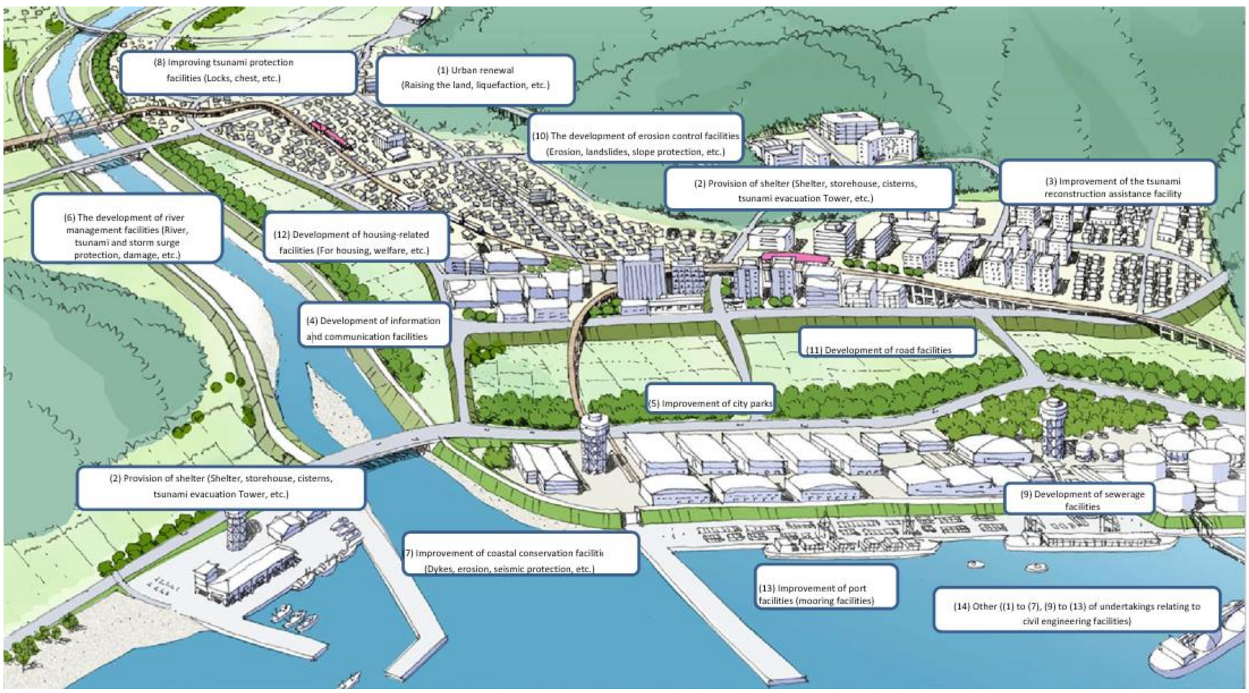

Fig. 10: Urban Recovery Projects at a Glance [22].

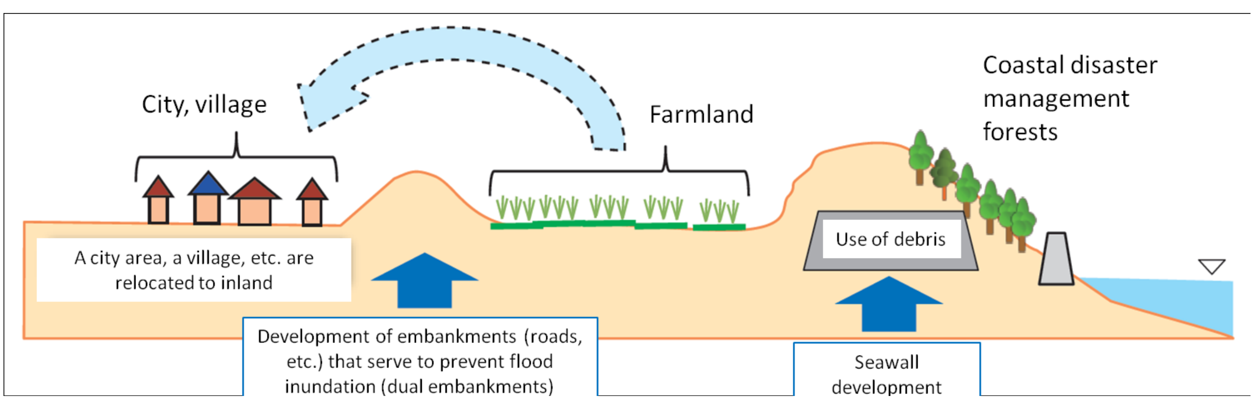

Fig. 11. Sample reconstruction model for a coastal area within Japanese Recovery Plan [3, 5, and 21].

At present the Miyagi prefecture is undergoing reconstruction. Management of the generated debris was completed in March 2014 [4]. As mentioned earlier, recycled debris is utilized in restoration, reconstruction and redevelopment projects. Fig. 12 presents the reconstruction timeline for the prefecture. The rebuilding of housing (public or private) began in 2014. Currently, land preparation for construction projects related to private housing is more than 50% complete. 63% of disaster related public housing is also completed at this time. [22]. Fig. 13 shows site preparation, cleared of debris and elevation raising of a project site in Kesennuma. Fig. 14 presents a billboard on the planned construction of Yuriage Town in Natori city. Residential structures will be constructed on higher ground to protect against future tsunami hazards.

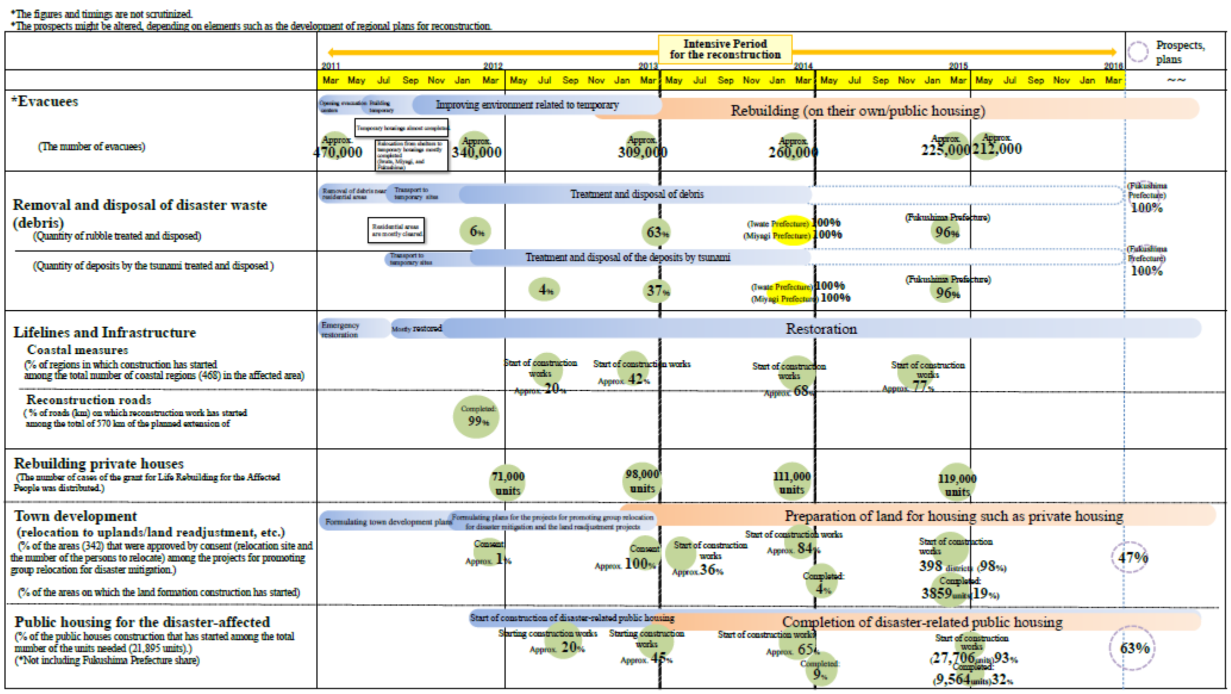

Fig. 12 Reconstruction timeline for Miyagi Prefecture [22].

Fig. 13: Land preparation for a housing project in the Kesennuma area (Sept. 2015).

Fig. 14: Construction billboard for Yuriage Town in Natori City (photo by T. Norton Oct. 2015).

Many of the planned reconstruction projects required that the land be raised to an elevation above the tsunami inundation height. Therefore, the recycled concrete debris and tsunami deposits will play an important role in this process. Debris materials are being stockpiled until time for its use. Figures 15 and 16 show debris storage piles. In addition, several restoration projects are underway to provide coastal protection. Figure 17 below presents the construction of a coastal levee or storm surge embankment being constructed in Natori city.

Fig. 15: Disaster waste storage piles for use in reconstruction projects (photo by T. Norton Oct. 2015).

Fig. 16: Storage piles in Minami-sanriku, Miyagi pref. (photo by T. Norton Oct. 2015).

Fig. 17: Levee under construction in Natori City (photo by T. Norton Oct. 2015)

4. Conclusion

The 2011 Great East Japan (Tohoku) Earthquake and Tsunami were extremely destructive to the coastal townships, industrial fishing and farming communities. The Miyagi prefecture had the challenge of managing more debris than the other affected areas. By following the lead of Sendai City, the entire prefecture was able to meet the two year debris processing timeline imposed by the Japanese government. In addition, new technologies were developed to use recycled waste for the reconstruction. The debris is being stored until it is ready for use within a public works project. At present the prefecture is mid-way through the reconstruction process. Many of the project sites have been prepared for the reconstruction and development of private and public housing. The next steps of this work includes:

1. Conduct a case study of debris management, including the recycle and reuse of debris for reconstruction, in both the Iwate and Fukushima prefectures.

2. Complete a comparative analysis of debris management in Japan over time, including historical disasters like the 1923 Great Kanto Earthquake and the 1995 Kobe Earthquake.

5. Acknowledgements

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