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Utilization of oil-based drilling cuttings pyrolysis residues of shale gas for the preparation of non-autoclaved aerated concrete

Chao-qiang Wang [a,b,c,d], Xiao-yan Lin [a,c,*], Dan Wang [b,d], Ming He [b,d], Si-lan Zhang [b,d]

[a] School of Materials Science and Engineering, Southwest University of Science and Technology, Mianyang 621010, Sichuan Province, China
[b] Chongqing Environmental Protection Center for Shale Gas Technology & Development, Fuling 400800, Chongqing, China
[c] Technology and Engineering Research Center of Biomass Materials, Ministry of Education, Southwest University of Science and Technology, Mianyang 621010, Sichuan Province, China
[d] Chongqing Environmental Protection Engineering Technology Center for Shale Gas Development, Fuling 408000, Chongqing, China

HIGHLIGHTS

- Original ODPR was utilized for the preparation of aerated concrete.
- Non-autoclaved curing technology was adopted for the preparation of aerated concrete.
- All physical performance of ODPR ONAAC met the requirements of Chinese standard.
- The environmental performance of ONAAC was very well.

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ABSTRACT

The overall objective of this research project is to investigate the feasibility of incorporating oil-based drilling cuttings pyrolysis residues (ODPR) and fly ash for the preparation of non-autoclaved aerated concrete. Within this thesis, mechanical and physical properties, detailed environmental performance, and microstructure analysis were carried out. Meanwhile, the early hydration process and hydrated products of ODPR non-autoclaved aerated concrete (ONAAC) were analyzed with X-ray diffraction analysis (XRD), Fourier transform infrared (FT-IR) and scanning electron microscopy (SEM). The results showed that the following optimal mix proportion is ideal for preparing ODPR non-autoclaved aerated concrete (about 600 kg/m^3), that is to say, is 25–30% for fly-ash, 15–20% for ODPR, 20–30% for cement, 15–20% for quicklime and 4% for gypsum, W/S is 0.61. Furthermore, the best curing steam temperature is 80 °C. The compressive strength, dry unit weight and thermal conductivity of products can basically meet the requirements of Chinese standard GB 11969-2008. The results also showed that ODPR had a certain pozzolanic activity which could play the role of active materials. Environmental performance tests came to the conclusion that when ODPR serves as recycled aggregates and admixture for preparation of non-autoclaved aerated concrete, from the technique's perspective, it wouldn't be the substance of environmental contamination.

1. Introduction

With the rapid development of China's economy, energy demand has constantly been increasing, and shale gas, as a new type resource of energy, has become one of the major motivations in the economic development of China. In the course of exploration and development of shale gas, we used oil-based drilling fluid of multi-interval fracturing technology in horizontal well for gas discovery, and then oil-based drillings were circulated to ground which included oil-based cuttings as well as a certain portion of oil-based mud. The pre-processes of oil-based drilling fluid and cuttings are presented in Fig. 1. All the processes were mainly via the vibrating screen system, which made the oil-based drilling cuttings available. In one well, approximately 250 m^3 of oil-based cuttings would be generated. Moreover, it is a kind of oily solid waste, thus pyrolysis procedures were used to ensure the safe discharge. The oil-based residues' oil content would be controlled within 0.3% so that it can guarantee solidification treatment [1,2].

* Corresponding author at: Institute of School of Materials Science and Engineering, Southwest University of Science and Technology, Sichuan Province, China.
E-mail address: linxiaoyan@swust.edu.cn (X.-y. Lin).

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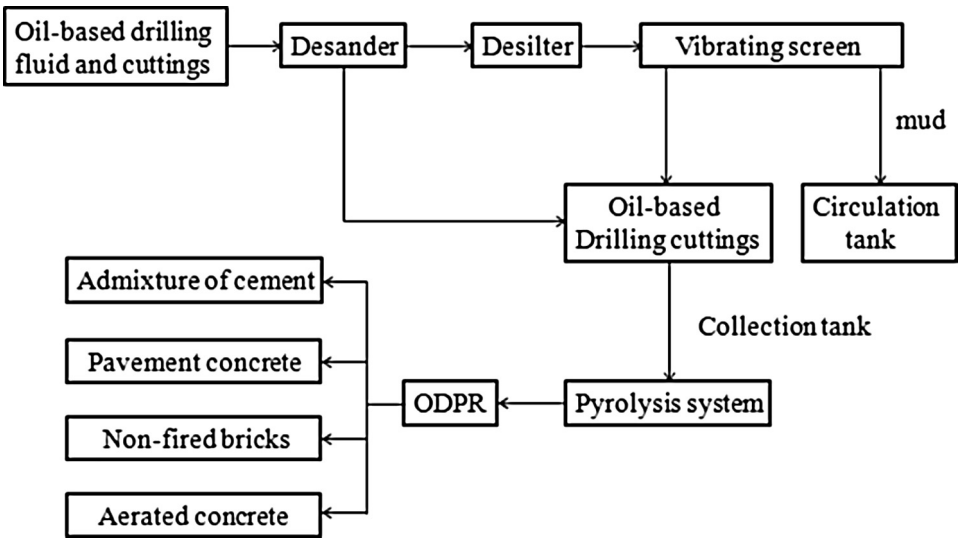

Fig. 1. Pre-processes of oil-based drilling cuttings and comprehensive utilization of ODPR.

We can add hardening agent such as cement in ODPR to convert it into solids with certain levels of strength. In this way, the contamination of ODPR can basically be solved within a short period of time. Technically, the absolute majority of contaminants, through solidification [2–5], in the ODPR were mixed in the solidified blocks, so effective treatment could be achieved. However, this process only mixed the pollutants in the solidified blocks rather than completely counteracting them. When buried underground for a long time, the solidified blocks would undergo a series of variations under physical, chemical and biological effects, thus resulting in the formation of secondary-pollution [6–8]. From Fig. 2, we can see that the solidifying processes of ODPR are very tedious. It mainly passes through the first and the second mixture with an agent, then it is solidified in a consolidation tank. In addition, there are also some problems; for example, large areas were occupied, high cost during building among others. What's worse, if construction had not been controlled well, there would be risks of in environmental pollution [2]. So the ODPRs' safe and environmental disposal as well as resource recycling by the exploration and development of shale gas are urgently needed.

Up until now, no studies have been done on the utilization of ODPR for preparing non-autoclaved aerated concrete. A new non-autoclaved aerated concrete was prepared by the ODPR in this study, therefore ODPR was used as a raw material for the preparation of ONAAC. Besides, this research used the non-autoclaved technology, which can conserve energy and environment.

The present study investigates the ODPR's potential possibility of resource utilization as a partial replacement of cementitious materials to make non-autoclaved aerated concrete will be discussed. The innovation which results from this study is not only produced a new and cost-effective material from drill cuttings, but also mitigated its negative environmental impacts. To achieve the goal mentioned above, mechanical and physical properties, detailed environmental performance, and microstructure analysis were carried out. Meanwhile, modern analytical methods have been used to investigate the early hydration process and hydrated products of ODPR non-autoclaved aerated concrete. This study can effectively solve the problem of ODPRs' safe and environmental disposal and resource recycling. On the other hand, it will play a role of standard guidance in drillings resource utilization by the exploration and development of shale gas in our country.

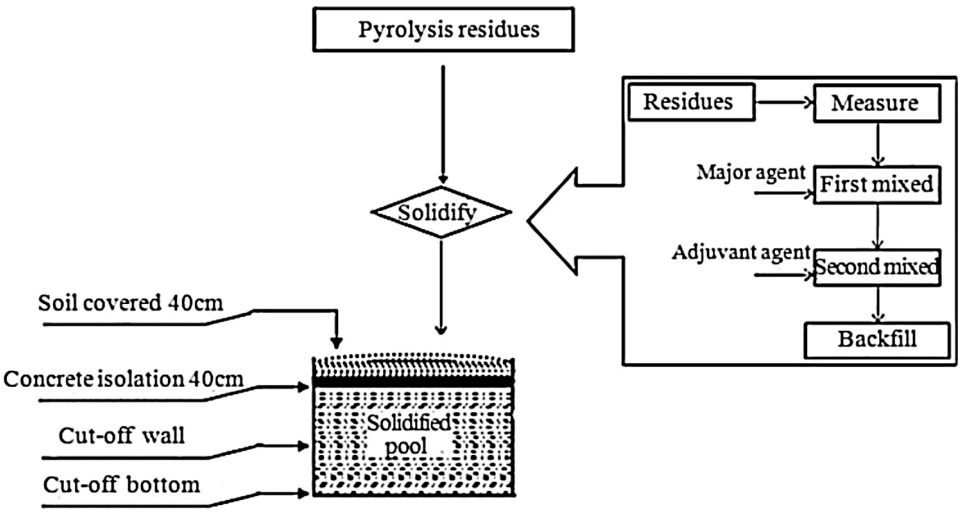

Fig. 2. Solidify processes of ODPR.