

# Study on the Adhesive for the Production of High Strength Four Layer Composite Corrugated Board

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## Abstract

In order to study of adhesive which is applicable to the production of high strength four layer composite corrugated board, the composite corrugated medium was respectively coated with cassava starch adhesive, environmental-friendly modified water glass binder, CP-88 starch adhesive, polyvinyl alcohol adhesive and polyvinyl acetate adhesive, then the edgewise crush resistance and flat crush resistance contrast experiment on produced corrugated board samples was tested. The experiment results demonstrated that the produced corrugated board with environmental- friendly modified water glass binder had high edgewise crush resistance, general flat crush resistance and more economic, so the environmental-friendly modified water glass binder can be used for the production of high strength four layer composite corrugated board.

**Keywords:** *Four Layer Composite Corrugated Board; Adhesive; Production Experiment; Test and Analysis of Strength*

## 1 INTRODUCTION

In recent years, with the production technology of corrugated board continually improved, the structure of corrugated board is also constantly innovating. According to the layers of corrugated board, some new products of corrugated board have appeared in the even number layers of paperboard, such as the four layer, six layer, eight layer corrugated board<sup>[1,2]</sup>, and the strength properties of this kind of corrugated board is improved obviously. Four layer composite corrugated board is a kind of reinforced corrugated board with the structure of double corrugating medium paper in between inner layer and face layer<sup>[3]</sup>, the structure schematic is shown in Fig. 1. The six layer is based on the four layer and combined with one layer of single face corrugated board, eight layer and so on. These even number layers corrugated board are no difference with ordinary corrugated board in appearance, double corrugating medium paper is attached tightly and not easy to be observed, but the properties such as edgewise crush resistance and puncture strength are significantly higher than the same thickness of ordinary corrugated board<sup>[4]</sup>. The four layer, six layer corrugated board which has the advantage of strength and thickness have been widely used in packaging heavy load chemical, mechanical and electrical products for transportation. An auto parts packaging box in contents weight 500kg was made with eight layer composite corrugated board, and the box which stacked three high and exported to Europe and America had no quality problems<sup>[5]</sup>. One of the key technologies for the production of new high strength composite corrugated board lies in selecting appropriate adhesive. Therefore, the study has a practical significance.



FIG. 1 FOUR LAYER COMPOSITE CORRUGATED BOARD

In order to select ideal adhesive, the composite corrugated medium in production experiments was respectively

coated with cassava starch adhesive, environmental-friendly modified water glass binder, CP-88 starch adhesive, polyvinyl alcohol adhesive and polyvinyl acetate adhesive<sup>[6]</sup>, and then the edgewise crush resistance and flat crush resistance contrast test on produced corrugated board samples was tested<sup>[7]</sup>.

## 2 EXPERIMENT

### 2.1 Raw Material

The four layer composite corrugated board (single C corrugated board, see Fig. 1) was made by Tat Seng Packaking(Suzhou) Co.,Ltd (hereinafter referred to as Tat Seng Packaing); The cassava starch adhesive(viscosity 20-40s) was prepared by the Tat Seng Packaing on-site; The environmental-friendly modified water glass binder was offered by Wang Ting Center Chemical Factory; The CP-88 starch adhesive was purchased from Israel Kamel Company; The polyvinyl alcohol adhesive was offered by Suzhou Helen Chemical Co., Ltd; The polyvinyl acetate adhesive was developed by Anhui Wuhu Star Synthetic Materials Company.

### 2.2 Equipment

The corrugated board for experiment was produced by Tat Seng Packaging using Germany BHS company's corrugated board high-speed automatic production line<sup>[8]</sup>.

### 2.3 Instrument

The edgewise crush resistance sampling instrument was made by Sichuan Changjiang papermaking instrument Co. Ltd.; The flat crush resistance sampling instrument was made by Sichuan Changjiang papermaking instrument Co. Ltd.; The edgewise / flat crush resistance strength tester was made by Sichuan Changjiang papermaking instrument Co. Ltd.; The thickness testing instrument was made by Changchun paper testing machine company; The quantitative testing instruments was made by Changshu Shuangjie testing instrument factory.

### 2.4 Method

#### 1) Experimental Preparation

The cassava starch adhesive by mixing outsourcing cassava starch and water in the ratio of 1:3 and adding the appropriate amount of additives was made into a paste adhesive, and then the adhesive was pumped into the glue tank of the corrugated board production line for production experiment.

The environmental-friendly modified water glass binder by outsourcing was pumped into the glue tank of the corrugated board production line for production experiment.

The CP-88 starch adhesive by mixing CP-88 waterproof agent and starch in the ratio of 1:30 was pumped into the glue tank of the corrugated board production line for production experiment.

The polyvinyl alcohol adhesive by mixing outsourcing 220 type polyvinyl alcohol and water in the ratio of 1:10 was pumped into the glue tank of the corrugated board production line for production experiment.

The polyvinyl acetate adhesive by mixing vinyl acetate, polyvinyl acetate emulsion and water in the appropriate ratio was pumped into the glue tank of the corrugated board production line for production experiment.

Respectively using the above adhesives the four layer composite corrugated board was produced in corrugated board production line. When the speed reached 1.36m/s and the temperature of the hot plate reached 178°C, the corrugated board test sample began to product. After placing test sample 24 hours the edgewise crush resistance and flat crush resistance was tested.

#### 2) Test Experiment

The test experiments were divided into two groups, the first group was comparison of the strength of corrugated board which was respectively coated with cassava starch adhesive, and environmental-friendly modified water glass binder or CP-88 starch adhesive. The second group is comparison of the strength of corrugated board which was

respectively coated with cassava starch adhesive, polyvinyl alcohol adhesive or polyvinyl acetate adhesive. The main testing indexes include edgewise crush resistance and flat crush resistance.

According to national standard GB6546-1998 The determination method of corrugated board's edgewise crush resistance the edgewise crush resistance was tested [9]. According to national standard GB/T22874-2008 The determination method of single side and single wall corrugated board's flat crush resistance the flat crush resistance was tested [10].

### 3 RESULT AND DISCUSSION

#### 3.1 The Comparison of the Edgewise Crush Resistance Test Results of the Corrugated Board Respectively with Cassava Starch Adhesive, Environmental-friendly Modified Water Glass Binder or CP-88 Starch Adhesive

The edgewise crush resistance test results of the corrugated board respectively with cassava starch adhesive, environmental-friendly modified water glass binder or CP-88 starch adhesive are shown in Fig. 2. From the chart, we can conclude that edgewise crush resistance test value of corrugated board with environmental-friendly modified water glass binder was higher, which reached a maximum value of 1007.9 N/m on tenth data, and twelfth data increased by 5.9% over the CP-88 starch adhesive corrugated board and increased by 16.4% over the cassava starch adhesive corrugated board.

After analysis, a conclusion can be drawn that edgewise crush resistance test value of corrugated board with environmental-friendly modified water glass binder was higher, and the water glass binder can be used as undetermined adhesive in experiment, and the binder was good in the process of experiment and suitable for the production line and can ensure the smooth production of corrugated board.

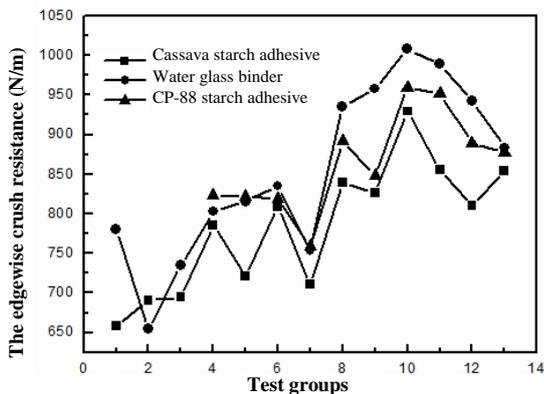


FIG. 2 THE COMPARISON OF THE EDGEWISE CRUSH RESISTANCE OF THE CORRUGATED BOARD WITH CASSAVA STARCH ADHESIVE, WATER GLASS BINDER OR CP-88 STARCH ADHESIVE

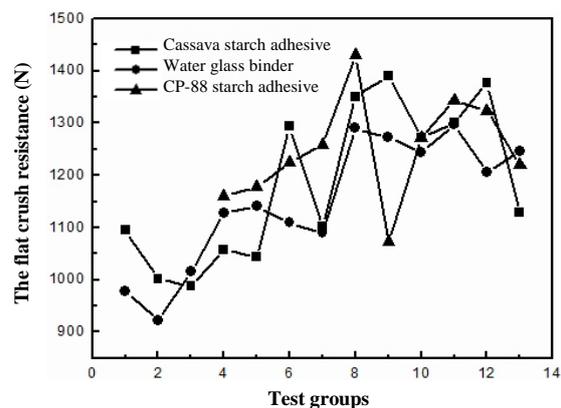


FIG. 3 THE COMPARISON OF THE FLAT CRUSH RESISTANCE OF THE CORRUGATED BOARD WITH CASSAVA STARCH ADHESIVE, WATER GLASS BINDER OR CP-88 STARCH ADHESIVE

#### 3.2 The Comparison of the Flat Vrush Resistance Test Results of the Corrugated Board Respectively with Cassava Starch Adhesive, Environmental-friendly Modified Water Glass Binder or CP-88 Starch Adhesive

The flat crush resistance test results of the corrugated board respectively with cassava starch adhesive, environmental-friendly modified water glass binder or CP-88 starch adhesive are shown in Fig. 3. From the chart, we can conclude that flat crush resistance test value of corrugated board with cassava starch adhesive was higher. While the flat crush resistance test value of corrugated board respectively with environment-friendly modified water glass binder and CP-88 starch adhesive had appeared unstable change.

Through comprehensive analysis of Fig. 2 and Fig. 3, we point out that edgewise crush resistance test value of

corrugated board with environmental-friendly modified water glass binder was higher and the flat crush resistance was not very ideal. The experimental research is focused on improving the empty cartons compressive strength which is closely related with edgewise crush resistance of paperboard, but is loosely related with flat crush resistance, so the preliminary selection of adhesive was still the environment-friendly modified water glass binder.

### 3.3 The Comparison of the Edgewise Crush Resistance Test Results of the Corrugated Board Respectively with Cassava Starch Adhesive, Polyvinyl Alcohol Adhesive or Polyvinyl Acetate Adhesive

The edgewise crush resistance test results of the corrugated board respectively with cassava starch adhesive, polyvinyl alcohol adhesive and polyvinyl acetate adhesive are shown in Fig. 4. From the chart, we can conclude that the difference of edgewise crush resistance test results between the corrugated board with polyvinyl alcohol adhesive and polyvinyl acetate adhesive was inconspicuous, and both were higher than that of corrugated board with cassava starch adhesive. But in the experiments, it's discovered that polyvinyl alcohol adhesive must be inject into glue groove immediately after completing preparation, otherwise there would be a binder agglomeration phenomenon which would affect the next use, so polyvinyl alcohol adhesive is not the preferred choice of adhesive. From the graph, we can conclude that eighth data of edgewise crush resistance test value of corrugated board with polyvinyl acetate adhesives reached 1025.6N/m, which increased by 14.6% over the cassava starch adhesive corrugated board. But in process of the experiments, after using the polyvinyl acetate adhesives the bubble appeared, and needs to be further improved.

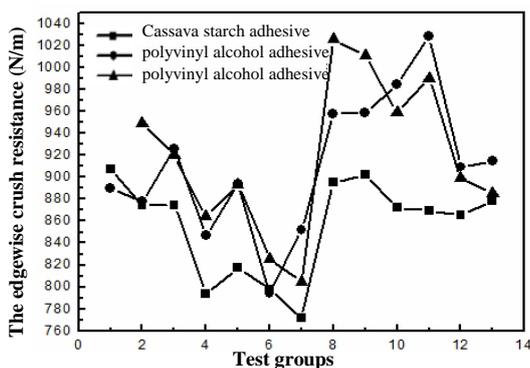


FIG. 4 THE COMPARISON OF THE EDGEWISE CRUSH RESISTANCE OF THE CORRUGATED BOARD WITH CASSAVA STARCH ADHESIVE, POLYVINYL ALCOHOL ADHESIVE OR POLYVINYL ACETATE ADHESIVE

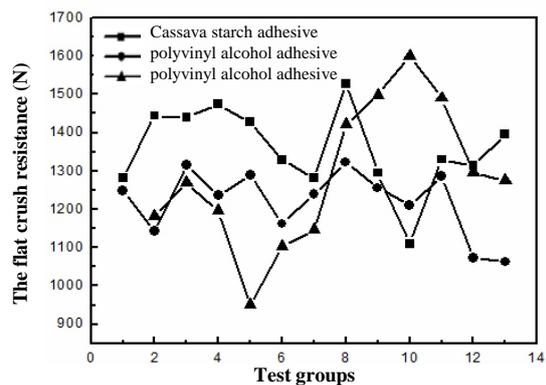


FIG. 5 THE COMPARISON OF THE FLAT CRUSH RESISTANCE OF THE CORRUGATED BOARD WITH CASSAVA STARCH ADHESIVE, POLYVINYL ALCOHOL ADHESIVE OR POLYVINYL ACETATE ADHESIVE

### 3.4 The Comparison of the Flat Crush Resistance Test Results of the Corrugated Board Respectively with Cassava Starch Adhesive, Polyvinyl Alcohol Adhesive or Polyvinyl Acetate Adhesive

The flat crush resistance test results of the corrugated board respectively with cassava starch adhesive, polyvinyl alcohol adhesive or polyvinyl acetate adhesive are shown in Fig.5. The figure shows that the curve of the flat crush resistance of the corrugated board respectively with polyvinyl acetate adhesive fluctuated greatly. This may be due to insufficient adhesive amount in corrugated board production and necessary to use artificial stirring adhesive to meet the needs of production. The flat crush resistance test value of the corrugated board with cassava starch adhesive was generally higher than that of polyvinyl alcohol adhesive, of which thirteenth data improved maximum, was up to 1395.9N/32.2cm<sup>2</sup> and increased by 31.4% over the polyvinyl alcohol adhesive corrugated board. Compared to the polyvinyl acetate adhesive corrugated board, fifth data of cassava starch adhesive corrugated board improved maximum, was up to 1427.4N/32.2cm<sup>2</sup> and increased by 50.2% over the polyvinyl acetate adhesive corrugated board.

## 4 CONCLUSION

In the experiment, the corrugated board samples for test were made with four layer composite corrugating medium which was respectively coated cassava starch adhesive, environmental-friendly modified water glass binder, CP-88 starch adhesive, polyvinyl alcohol adhesive and polyvinyl acetate adhesive, then the edgewise crush resistance and flat crush resistance contrast test on the five corrugated board samples were tested. Through data analyzing, we can conclude that edgewise crush resistance of corrugated board with environmental-friendly modified water glass binder was higher, and flat crush resistance was general. With respect to the cassava starch adhesive corrugated board, the increasing rate of strength of environmental-friendly modified water glass binder corrugated board was bigger, and the processing cost was lower and more economic, so the environmental-friendly modified water glass binder can be used as adhesive for the production of high strength four layer composite corrugated board.

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