CERAMICS AND RECYCLED-GLASS INTEGRATION METHODOLOGY STUDY: AN APPLICATION OF DECORATIVE LIGHTING DESIGN.

By
MRS. Weeraya JUNTRADEE

A Thesis Submitted in Partial Fulfillment of the Requirements for Doctor of Philosophy DESIGN ARTS (INTERNATIONAL PROGRAM)
Graduate School, Silpakorn University
Academic Year 2019
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การผสมผสานศิลปะเครื่องเคลือบดินเผาและศิลปะแก้วในการออกแบบแสงสว่างเพื่อการตกแต่ง

โดย

นางวีรยา จันทรดี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปรัชญาดุษฎีบัณฑิตสาขาวิชาศิลปะการออกแบบ แบบ 1.1 ปรัชญาดุษฎีบัณฑิต(หลักสูตรนานาชาติ)

บัณฑิตวิทยาลัย มหาวิทยาลัยศิลปากร
ปีการศึกษา 2562
ลิขสิทธิ์ของบัณฑิตวิทยาลัย มหาวิทยาลัยศิลปากร
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Title: Ceramics and Recycled-Glass Integration Methodology Study: An Application of Decorative Lighting Design.

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Field of Study: DESIGN ARTS (INTERNATIONAL PROGRAM)

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Ceramics and glass exist in the same group of materials; compounded by the same inorganic substances and with which when treated with heat exhibit a very similar transformation process. However, they are structurally different resulting in varying rates of expansion and shrinkage. This creates incompatibility problems, in the form of excessive cracks or stresses when they are combined. This research aims to experiment to find possibilities of combining ceramics and recycled glass for decorative lighting design regarding both materials share similar characteristics with regard to passage of light and their translucency.

The research methodology was related to practice-based research, consisted of research in art and design and pure practice process which were implemented to identify potential compatibility and combining techniques. The development of these techniques were based-on a review of relevant literature, analyzed and concluded into 3 possible processing routes. Quartz added bone china clay body was identified and used with recycled bottle and window glass in the exploration. The kiln-formed techniques; fusing, slumping and casting were used to create the prototype artwork. Design inspiration was drawn from “Star ceiling: patterns and elements from Thai Traditional Architecture” and simplified version of these elements were used in the design to make contemporary artworks while at the same time maintaining a sense of Thai-ness and reflecting the artistic identity of the researcher.

The experimentation results are present in the prototype artworks as follow; lighting sculptures, stained glass partition and table lamps which are demonstrated the translucency enhancement of ceramic clay body combining with recycled glass. Furthermore, this research also expected to raise society’s awareness and aesthetic appreciation of ceramic and recycled glass design which will be able to benefit the further development of creative art and eco-friendly design product in the future.
ACKNOWLEDGEMENTS

This research was accomplished with the supported from my Ph.D. advisors, Asst. Prof. Veerawat Sirivesmas, Ph.D., and Asst. Prof. Jirawat Vongphantuset, Ph.D. I greatly appreciated for their guidance and valuable support throughout fulltime study of this research. I am very grateful to Assoc. Prof. Pairoj Jamuni, Ph.D. for his enthusiastic and energetic support for my research. I am also thankful to the members of my Ph.D. committee, Prof. Eakachart Janeurairatana, Assoc. Prof. Son Srimatrang and Prof. Dr. Mustaffa Halabi Azahari for their helpful advice and suggestions.

I would like to express my deepest gratitude to my family for their support, especially my mother for her helpful take care of my children, my husband for his encouragement and professional technical support and Prof. Kemrat - Assoc. Kornthana Kongsuk for their inspired recommendations.

My sincere thanks also goes to Mrs.Varangkana Klinsukol, Head of Product Engineering K & B Thailand, Royal Porcelain Public Company Limited and Kiln Design Company Limited for the technical guidance and materials support.

Finally, special thanks and appreciation to the Office of Traditional Arts, Fine Arts Department, Ministry of Culture for the great opportunity to further my study in this Ph.D. Program to develop my academic capabilities which I expect to be able to enhance my work efficiently for the benefit of the organization.

Weeraya JUNTRADEE
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Chapter 1
Introduction

1.1 Background

“CERAMICS AND RECYCLED-GLASS INTEGRATION METHODOLOGY STUDY: AN APPLICATION OF DECORATIVE LIGHTING DESIGN.”

Ceramics and Glass art both have long rich history for many thousand years that express the prosperity of art & culture through amazingly versatility of these materials and manufacturing process. In ceramic arts it was discovered that intense heat could transform clay into a material of great durability, from this point onwards, exploration of the practical possibilities of the material went hand in hand with development of its aesthetic potential.

Clay is an extraordinary substance: very plastic and malleable, it can also be poured as liquid or carved and scraped in a dry state. Many decorative techniques can be applied in clay such as painting with under glazed / over glazed color. The discovery of glazes makes vessels impervious to liquid. Clay undergoing with wide range of firing temperature from earthenware to porcelain -can be decorated with suitable glaze and firing technique. (Dormer, 1994)

Ceramic materials encompass a diverse range of possibilities which extend from functional / useful pieces that continue a long tradition to works that have no concern with function. Many sculptors nowadays use ceramic as a medium to express their creativities. “Clay is an ideal medium for those who want to make arbitrary gestures and marks in it. Very often it is allowed to take control of the maker and is used as a free vehicle for intuitive expression. (Dormer, 1994: 40)

Glass is an amazingly versatile material with character of magical, mysterious, illusory. Glass is a mixture of the most common materials (sand, chalk and wood ash) all can be transformed by fire into a unique transparent solid with marvelous optical qualities. It becomes more fluid as temperature rises, until at around 1000°C. It can be manipulated in a variety of ways. Molten glass can be blown, stretched and drawn into
threads, poured, rolled flat or cast into sheet or blocks. These can then be fused, bent or molded in a kiln and when cold can be cut sawn, drilled, carved, etched, engraved, polished, painted or laminated. Forms and images can be suspended within it, or magnified through it. It can be toughened and colored and it has ability to hold, transmit, bend, reflect, diffused or reflected light. (Layton, 1996) Ceramics and glass can be said that they are in the same group of materials because both are compounded by the same inorganic substances and using heat into transformation process but the different is glass have to be melt before forming while ceramic have to forming the clay first then heating to melt glaze into clay body; ceramic glaze made from the same basic substances of glass to coating the clay surface.

Currently, worldwide society immensely realizes and pays great attention to global warming, environmental and energy problems so that sustainable development has become one of the solutions to prevent and solve these problems. Sustainability can be defined as the practice of reserving resources for future generations without any harm to nature and other components. Sustainable energy, sustainable architecture, sustainable agriculture, sustainable design, these words are the example terms of knowledge based upon maintaining the core qualities whilst improving environmental impact. This research is expected to build on concepts and approaches to find the innovative design and knowledge contributions to experiment in the processing and use of recycled glass manufacturing conserves raw materials, and reduces energy consumption.

Glass recycling facts: Glass is ideal for recycling since none of the material is degraded by normal use. Glass bottles and jars are 100 percent useful and might be recycled endlessly with none loss in purity or quality. Recycled glass can be substituted for up to 95% of raw materials. Recycled glass is usually a part of the formula for glass, and therefore the additional that’s used, the bigger the decrease in the furnace and benefiting the environment.²

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2 Source: Glass Packaging Institute, http://www.gpi.org/recycling/glass-recycling-facts
1.2 Statements of the Problem

Glass and ceramics have many related material qualities and can be processed in similar ways. Chemically they are alike, however they are structurally very different; as ceramic is crystalline (composed of crystals) and glass is non-crystalline. This creates serious compatibility issues in term of expansion and shrinkage rates when they are combined. Through controlled processing, material properties can alter when each is partially converted into the other. It is recognized by artists in the field of studio ceramics that porcelain and bone china can partially convert into glassy form when high fired to create a translucent material. Likewise it is recognized in the field of industrial engineering that glass can partially convert into a ceramic form when processed in a controlled way to create a glass-ceramic material. (Kelly, 2009: 71)

Glass expands up to more than 1300 degrees, then begins to harden and set as the temperature drops while ceramic will contract until around 100 degrees. “The structural differences of ceramic and glass related to their varying rates of expansion which creates incompatibility, in form of excessive cracks or stresses in the combined body.” (Kelly, 2009: 22) In spite of this obstruction many artists still try to make a collaborative work of ceramics and glass - the two charming, magical and fascinating material of arts which deeply rooted in life and culture of people around the world. For example, Andrea Walsh and Jessamy Kelly from England. MisaTanaka and Etsuko Tashima from Japan. John Groth, Steven Brantman and Christina Bothwell from USA, etc. Their artworks show many possibilities of combining ceramic and glass in various techniques from cold state to hot state assembled. Mostly combine in cold state by gluing or juxtaposing the materials to avoid compatibility issues. In fact many have felt that it is a near impossible task and there is much debates about whether the hot state combination of ceramics and glass is actually possible.
1.3 Objectives:

The objectives of the research are as follows;

1. To understand the both materials of ceramics and recycled glass to be enhance in designing of lighting sets.
2. To experiment both materials above of ceramics and recycled glass to be formed and designed for lighting sets.
3. To design appropriate lighting sets from the selected tested combining materials for lighting sets.

1.4 Research questions

1. What are the suitable materials and process of ceramics and recycled glass to combine these both materials together?
2. How to experiment to combine ceramic and glass without incompatibility issues?
3. How to create the designing lighting sets of combining ceramic and recycled glass?

1.5 Scope of the research

1. Material and process of ceramic and recycled glass
2. Possibilities of combining ceramic and recycled glass
3. Experimentations
4. Design and making the artwork
5. Aesthetic value of combining ceramic and recycled glass for lighting design

1.6 Significance of the Research

This study aims to research the possibility of ceramics and recycled glass combination for decorative lighting design due to the shared characteristics of ceramic and recycled glass related with light and translucency. The findings will introduce new visual language and aesthetic value of combining ceramic and recycled glass for lighting design in various ways such as Light Art Installations, Decorative Lighting Design etc.
In Thailand nowadays, the number of contemporary artists and designers, studio potters, ceramic artists and glass artists are increasing but most of them often create work with separate materials that they specialize in some works of ceramic combined with wood, natural basketry materials or metal are found but we have not found anyone who tries to combine ceramic and glass together in hot state and make any distinctive progress. Therefore, it is interesting and challenging to study, research and experiment in combining ceramics and recycled glass to make a decorative lighting design. Furthermore this project result also create the knowledge of combining ceramic and recycled glass both material & process and aesthetic value. Expected to raise society’s awareness and aesthetic appreciation of ceramic and recycled glass design which will be able to benefit the further development of creative art and eco-friendly design product in the future.

1.7 Definitions of Keywords:

Key word: Ceramics, Recycled glass, Integration and Decorative Lighting

Definition

1. Ceramics: In this research scope down ceramic clay body to porcelain and bone china which were used in the experimentation.

2. Recycled glass: In this research scope down recycled glass to recycled bottle glass from household used and recycled window glass.

3. Integration: In this research integration means to combining ceramic and recycled glass by kiln-forming techniques which refer to fusing, slumping and casting techniques.

4. Decorative Lighting: In this research decorative lighting means the design prototype artworks in lighting decorative items such as lighting sculpture, stained glass partition and table lamps.

1.8 The overview of the thesis

The overall thesis is comprised of 5 chapters. Chapter 1 is focused on introduction and background of this research. This includes the introduction and
backgrounds of the research, the statements of the problems, objectives, keywords, and the significance of the research.

Chapter 2 is focused on the Literature reviews and related studies based on the key themes and words of: ‘Subject of research’- Ceramics and Recycled glass.

‘Variable of Research’- Designing lighting sets by integrating.

Chapter 3 is focused on the Research Methodology that is employed in the process of collecting data or information. The overall research data collection is employed by using Qualitative or Quantitative research approaches in the two phases of data collection processes.

Chapter 4 is emphasized on the discussion of findings of second phase of data collection processes. Meanwhile Chapter 5 is emphasised on the conclusion and recommendation of the research and to fulfil the Research Objectives.
2.1 Literature Reviews

The researcher tried to search for the artworks that combined ceramic and glass together as much as possible in the specific research timeline. The results are these 53 artworks of designers and artists worldwide which can be categorized and demonstrated into the groups as shown in the following diagram. (Fig. 1)

Total amount of 53 artworks is subdivided into 2 groups; 1. Design (15 pieces) and Fine Arts (38 pieces)

1. Design:
   1.1 Lighting (6 pieces)
   1.2 Tableware (4 pieces)
   1.3 Decorative items (5 pieces)
2. Fine Arts:

2.1 Functional Art Objects (6 pieces)

2.2 Art Objects:

2.2.1 Cold State Assembled

2.2.1.1 Figurative Sculpture (4 pieces)

2.2.1.2 Mixed media (4 pieces)

2.2.1.3 Sculptural Form (11 pieces)

2.2.2 Warm State Assembled (6 pieces)

2.2.3 Hot State Assembled (7 pieces)
1. Design Group

1.1 Lighting

Table 1 Detail of Design group/Lighting.

<table>
<thead>
<tr>
<th>Design group/Lighting</th>
<th>Angel Lamp: Dhanabadee (Thailand) 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slip cast bone china</td>
</tr>
<tr>
<td></td>
<td>Blown glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Angel Lamp³</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design group/Lighting</th>
<th>Domlight: Matteo Cibic (Italy) 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slip cast porcelain by Bosa Ceramiche</td>
</tr>
<tr>
<td></td>
<td>Blown pyrex glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Domlight⁴</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design group/Lighting</th>
<th>Duo table lamp: Tom Housden (UK)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hand &amp; Eye Studio 2013</td>
</tr>
<tr>
<td></td>
<td>Slip cast terracotta</td>
</tr>
<tr>
<td></td>
<td>Blown opal glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Duo table lamp⁵</td>
<td></td>
</tr>
</tbody>
</table>


⁵ Source: http://handandeyestudio.co.uk/products/ Accessed December 16, 2016
Table 2 Detail of Design group/Lighting.

<table>
<thead>
<tr>
<th>Design group / Lighting</th>
<th>Parachilna Chinoz Lamps: Jaime Hayon (Spain) 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coloured glazed slip cast ceramic</td>
</tr>
<tr>
<td></td>
<td>Opal matt white diffuser glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Parachilna Chinoz Lamps</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Trumpet: Matteo Zorzenoni (Italy) 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slip cast terracotta</td>
</tr>
<tr>
<td></td>
<td>Blown opal glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Trumpet</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Verceram Ceramique (France) 1950</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coloured glazed slip cast ceramic</td>
</tr>
<tr>
<td></td>
<td>Matt white diffuser glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Ceramic table lamp 1950s</td>
<td></td>
</tr>
</tbody>
</table>


---


Six artworks in this group, all of them are emphasized on functional use as the lighting. Therefore all of the ceramic and glass were designed by form follow function, produced separated and can be assembled together while using for easily use and maintenance. Various clay body were used; terracotta, stoneware, porcelain and bone china and formed by casting technique in industrial production. Both matt and clear glass were formed by blowing and casting. Most of ceramic work were design to function as a base of the lamp while glass were use as a light unit, except The Angel lamp which glass work was designed to be used as a base and the light unit made from craved bone china clay body.

1.2 Tableware

Table 3 Detail of Design group/Tableware

<table>
<thead>
<tr>
<th>Design group / Tableware</th>
<th>Andaman Table set: Chuanlhong Ceramic Ltd., Part. (Suwan Kongkhunthian) &amp; SACICT(Thailand) 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andaman Table set:⁹</td>
<td>Crushed glass is mixed into the ceramics to create a stunning unique design of colour and texture.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design group / Tableware</th>
<th>Ivan Jelinek (Czech) 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teapot silver on porcelain glass application¹⁰</td>
<td>Hand built porcelain gold decoration</td>
</tr>
<tr>
<td></td>
<td>Cast coloured glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
</tbody>
</table>


Table 4 Detail of Design group/Tableware

<table>
<thead>
<tr>
<th>Design group / Tableware</th>
<th>Shizukana Sora: Misa Tanaka (Japan) 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Porcelain</td>
</tr>
<tr>
<td></td>
<td>Cast glass</td>
</tr>
<tr>
<td></td>
<td>Warm stage assembled: fusing</td>
</tr>
<tr>
<td>Shizukana Sora</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( - )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rebecca Harvey (UK) 2007</th>
<th>Hand built porcelain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blown glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
</tbody>
</table>


There are 4 artworks in this group. All of them are also emphasized on functional use. Ceramic and glass were produced separated and assembled together later. The artwork of Ivan Jelinex casting colored glass were assembled with porcelain body by gluing together while Misa Tanaka’s work wheel thrown porcelain were fired in high temperature then fusing with casting glass in warm state assembled. The Andaman table set is different by using crushed glass mixed into the glaze of stoneware ceramic body then fired in high temperature to create a stunning unique design of color and texture of the artwork. Rebecca Harvey combined slip - cast porcelain and blown glass to express contrasts in texture and density of materials to reveal unexpected harmonies when the pieces are displayed together.

### 1.3 Decorative items

<table>
<thead>
<tr>
<th>Design group / Decorative Items</th>
<th>Andrea Walsh (UK) 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unglazed bone china clay</td>
</tr>
<tr>
<td></td>
<td>Kiln cast glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
</tbody>
</table>

Large Faceted Box<sup>13</sup>

<table>
<thead>
<tr>
<th>Design group / Decorative Items</th>
<th>Elinor Portnoy (UK) 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3D Printing Porcelain</td>
</tr>
<tr>
<td></td>
<td>Hand Blown glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
</tbody>
</table>

Acorn<sup>14</sup>

<table>
<thead>
<tr>
<th>Design group / Decorative Items</th>
<th>Piadesign: Pia Wüstenberg (Germany) 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raku ceramic, wood</td>
</tr>
<tr>
<td></td>
<td>Blown glass</td>
</tr>
<tr>
<td></td>
<td>Cold stage assembled</td>
</tr>
</tbody>
</table>

Pia design<sup>15</sup>


---

<sup>13</sup> Source: http://andreawalsh.co.uk/ Accessed December 16, 2016.


Table 6  Detail of Design group/Decorative Items

| Design group / Decorative Item | 
|--------------------------------|---------------------------------|---------------------------------|
|                                | Veronica Pöschl (Austria) 1983   | Hand built stoneware            |
|                                |                                 | Blown matt glass                |
|                                |                                 | Cold stage assembled            |
| Nr.17 16                       | ![Image](https://example.com/image1.png) |                              |
|                                | Transaction Project: Jonathan Keep & Design Unfold (USA)2014 | Unglazed 3D printing ceramic |
|                                |                                 | Blown glass in hot stage assembled with ceramic body |
| Transaction Project 17         | ![Image](https://example.com/image2.png) |                              |


Most of the artworks in this group are still produced separated like lighting and tableware group but have more varieties in the production techniques. The transformation project of Jonathan Keep and Design Unfold were used 3D printing technique to produced ceramic work and combined with blown glass in hot state assembled by blowing hot colored glass into 3D printing clay body to experiment various form, texture and color of the clay body and glass. The work of Elinor Portny also used 3D printing porcelain body but combine with blown glass in cold state assembled and can be separated and assembled for functional use.

The artwork of Andrea Walsh using unglazed bone china as a base of the facet box combined with kiln cast colored glass. She fired her work together using fiber paper to separate the two surfaces to create an exact fit. The complementary elements are then assembled in cold state to create a flawless connection that appears to be

---

one piece. The work of Pia Design using raku ceramic with blown glass and added wood work stack together to create unique design with variety of materials. Veronica Pöschl’s work used hand built stoneware clay and blown matt glass combine with cold state assembled. This work show the contrast of clay color and texture of matt glass.

2. Fine Arts Group

2.1 Functional Art Objects

Table 7 Detail of Fine Arts group/Functional Art Objects

<table>
<thead>
<tr>
<th>Fine Arts group / Functional Art Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judi Tavil (USA)</td>
</tr>
<tr>
<td>Hand built porcelain</td>
</tr>
<tr>
<td>Coloured glass</td>
</tr>
<tr>
<td>Warm stage assembled: fusing</td>
</tr>
<tr>
<td>Crackle effect</td>
</tr>
<tr>
<td>Porcelain dichroic glass</td>
</tr>
<tr>
<td>John Conrad (USA) 2016</td>
</tr>
<tr>
<td>Wheel thrown porcelain</td>
</tr>
<tr>
<td>Tenmoku/saturated metallic glaze</td>
</tr>
<tr>
<td>Pressure fused metallic silica to the</td>
</tr>
<tr>
<td>piece to finalize the multi-colour high</td>
</tr>
<tr>
<td>metallic finish</td>
</tr>
<tr>
<td>Karen Turner (UK) 2011</td>
</tr>
<tr>
<td>Hand built porcelain</td>
</tr>
<tr>
<td>Coloured glass</td>
</tr>
<tr>
<td>Warm stage assembled : fusing</td>
</tr>
<tr>
<td>Crackle effect</td>
</tr>
</tbody>
</table>


Table 8 Detail of Fine Arts group/Functional Art Objects

<table>
<thead>
<tr>
<th>Fine Arts group / Functional Art Object</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="160x160" alt="Image" /></td>
</tr>
<tr>
<td><strong>Nathan Anderson (USA) 2005</strong></td>
</tr>
<tr>
<td>Wheel thrown stoneware raku clay body</td>
</tr>
<tr>
<td>Hot molten glass</td>
</tr>
<tr>
<td>Hot stage assembled Crackle effect</td>
</tr>
<tr>
<td><img src="160x160" alt="Image" /></td>
</tr>
<tr>
<td><strong>Steven Branfman (USA)2002</strong></td>
</tr>
<tr>
<td>Wheel thrown stoneware</td>
</tr>
<tr>
<td>Coloured glass chip impressed into wet clay</td>
</tr>
<tr>
<td>Hot stage assembled / Glass melts to form a series of multi coloured glassy glaze runs</td>
</tr>
<tr>
<td><img src="160x160" alt="Image" /></td>
</tr>
<tr>
<td><strong>Seikishi Inamine (Japan)</strong></td>
</tr>
<tr>
<td>Blown recycled glass bottle</td>
</tr>
<tr>
<td>Surface finishing with Okinawa red clay &amp; Machiko white clay</td>
</tr>
</tbody>
</table>


There are 6 artworks in this group. Judi Tavil and Karen Turner works have similarity in using hand forming clay body and fusing crushed glass on the clay surface. The result have shown in the crackle effect and interested contrast of clay and glass texture. The work of Nathan Anderson used the hot molten glass on the wheel thrown raku fired ceramic work created the outstanding crackle effect of glass and raku texture. Steven Branfman inlayed small colored glass pieces into the wall of wet hand thrown vessels and fired in high temperature. The glass melts to form a series of multi colored glassy glaze runs.


Seikishi Inamine’s work was uniquely different from the other by using hot blown recycled glass bottle, put the hot glass into Machiko white clay slip and Okinawa red clay slip and then blown the glass into desired shape. This technique made unique crackle texture of 2 different clay colored on glass surface. John Conrad created the distinctive artwork of unique process called dichroic fused porcelain: a new ceramic medium that blends traditional and historical ceramic elements and glazing with the high tech process dichroic metallic “flashing” which used to produced dichroic glass by multiple ultrathin layers of different metals and oxides such as silica are vaporized by an electron beam in vacuum chamber, resulting in a metallic plasma effect treatment display rich brilliant rainbow of color that can be seen variant in different angle.

2.2 Art Objects

2.2.1 Cold state assembled

-Figurative Sculpture

Table 9 Detail of Art Objects/Cold state assembled/Figurative Sculpture

<table>
<thead>
<tr>
<th>Art Objects/Cold state assembled/Figurative Sculpture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christina Bothwell (USA) 2013</td>
</tr>
<tr>
<td>Raku fired ceramic</td>
</tr>
<tr>
<td>Kiln cast glass</td>
</tr>
<tr>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Dreaming in colour 24</td>
</tr>
<tr>
<td>Judy Hill (USA) 1997</td>
</tr>
<tr>
<td>Raku fired ceramic</td>
</tr>
<tr>
<td>Kiln cast glass</td>
</tr>
<tr>
<td>Cold stage assembled</td>
</tr>
<tr>
<td>Very Gently Now 25</td>
</tr>
</tbody>
</table>


All of 4 artworks in this group are hand forming ceramic work. Christina Bothwell combined cast glass and raku fired ceramics which she assembles in a cold state. She creates figurative sculptures which portray the processes of birth, death and renewal. A similar approach is that of Judy Hill, her doll-scale figures made of kiln-cast glass and raku fired ceramics; which she combines in a cold state. Her self-portraits are emotional studies which reveal and conceal private natures. Mandy long also use raku fired ceramic and install with cut float glass in order to render her figures airborne. Marianne Eggimann creates porcelain animals, human and landscape which are encased in a cold state under a dome of blown glass. The figures are enlarged by the water giving a strange focus to the surreal scenes.


### Mixed Media

**Table 11** Detail of Art Objects/Cold state assembled/Mixed Media

<table>
<thead>
<tr>
<th>Art Objects/Cold state assembled/Mixed Media</th>
</tr>
</thead>
</table>
| ![Fusion III](image1) | **Almut Flentje (Germany) 2013**
Raku ceramic, stone, wire, lead
Kiln cast glass
Cold stage assembled |
| ![Space I](image2) | **Julie York (USA) 2006**
Slip cast porcelain, glass, metal, plastic element, mixed media
Cold stage assembled |
| ![Seekers](image3) | **Kristin Stina Gudionsdottir (Iceland) 2001**
Ceramic, metal, stone, mixed media
Kiln cast glass
Cold stage assembled |
| ![Humanides Glass Fusing](image4) | **Nad Vallé (France)**
Raku ceramic, metal, mixed media
Kiln cast glass
Cold stage assembled |


---


Almut Flentje combines raku fired ceramics, cast glass, stone, wire, lead and textiles which she combines in a cold state to express the unique arrangement of materials while Julie York mixed media sculpture reflect her visual exploration of day-to-day experiences. Found objects are reproduced in slip cast porcelain juxtaposed with metal, glass and plastic elements. Kristin Stina Gudjonsdottir create mixed media abstract sculpture in cast glass, ceramic, metal and stone, all of the work is made from reused materials and found objects and is assembled in cold state. Nad Valleé works in both cast glass and raku fired ceramic assembled with metal in cold state.

**-Sculptural Form**

Table 12 Detail of Art Objects/Cold state assembled/Sculptural Form

<table>
<thead>
<tr>
<th>Art Objects/Cold state assembled/Sculptural Form</th>
</tr>
</thead>
</table>
| ![Meule VI](image1)  
**Christian Hadengue (France) 1990**  
Stoneware ceramic  
Cut sheet glass  
Cold stage assembled |
| ![Grand Rocher](image2)  
**Edmée Delsol (France) 1990**  
Raku fired terracotta  
Kiln cast glass  
Cold stage assembled |


---


Table 13 Detail of Art Objects/Cold state assembled/Sculptural Form

<table>
<thead>
<tr>
<th>Art Objects/Cold state assembled/ Sculptural Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Cornucopia 02-1" /></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Vluchtig" /></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Sensing the Silence:Mary Kathleen" /></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Grand affrontement - Pénétration II" /></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>


---

Table 14: Detail of Art Objects/Cold state assembled/Sculptural Form

<table>
<thead>
<tr>
<th>Art Objects/Cold state assembled/ Sculptural Form</th>
</tr>
</thead>
</table>
| ![Monolith Blue-green Mist, KT.3609](image) | **Kondo Takahiro (Japan) 2014**  
Porcelain decorated with glaze which draws link between the cast glass and ceramic surface  
Cold stage assembled |
| ![Vinterset](image) | **Mieke Pontier (Netherlands) 2008**  
Stoneware  
Blown glass  
Cold stage assembled |
| ![THE SOUND OF FIRE](image) | **Pilar Aldana-Méndez (Spain) 2011**  
Hand built ceramic  
Kiln cast glass  
Cold stage assembled |
| ![Spike](image) | **Ron Starr (USA) 2004**  
Stoneware sculptural and uses glass as an extension of glazing on ceramic  
Cold stage assembled |


---


Christian Hadengue, Edmée Delsol, Etsuko Tashima, Jenny Mulcahy, Jutta Cuny and Kondo Takahiro works have similar approach by assembles ceramic and glass as one piece in cold state to express the contrasts between the transparent and opaque qualities of the materials. While Pilar Aldana-Méndez works are juxtaposed kiln cast glass and raku fired ceramic together. Christian Hadengue create abstract ceramic sculpture combine with glass sheet. Edmée Delsol combine raku fired terrecotta with cast glass. Etsuko Tashima sculptures merge flower and animal, petal and bone to create subtly erotic composition. She uses strong contrasts between glossy opaque surface of the glass and the matt and unglazed ceramic form. Closely aligned is the work of Kondo which his ceramics are complimented by thick blocks of glass. Ceramic glaze resemble dew, which draws links between the cast glass and ceramic surface. Jutta Cuny combined porcelain with optical crystal which she carved by using deep sandblasting techniques.

Helly Oestreicher use extruded stoneware ceramic elements assembles with sheet glass to create her sculpture work. Tatiana Best Devereux combined kiln cast glass cores with her hand built ceramic, as similar with the work of Mieke Pontier which combined stoneware with blown glass to create her one of sculptures inspired by nature. Ron Starr uses glass as an extension of glazing on his stoneware sculptural vessels. He assembles his work in cold state aligning the contrasting qualities of the two materials in one piece.

2.2.2 Warm state assembled

Table 16 Detail of Art Objects/Warm state assembled

<table>
<thead>
<tr>
<th>Art Objects/Warm state assembled</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="https://example.com/image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Claire Phillips Thomas (UK) 2009</td>
</tr>
<tr>
<td>Slip cast ceramics, paper pulp</td>
</tr>
<tr>
<td>Coloured glass</td>
</tr>
<tr>
<td>Warm stage assembled: Slumping</td>
</tr>
</tbody>
</table>

| ![Image](https://example.com/image2.jpg) |
| Claude Bromet (France) 2004 |
| High fired ceramic setter |
| Coloured glass frit |
| Hot stage firing and have crackle effect |

| ![Image](https://example.com/image3.jpg) |
| Emily Barber (UK) 2011 |
| Hand built stoneware |
| Thick float glass |
| Warm stage assembled: Slumping |

| ![Image](https://example.com/image4.jpg) |
| John Groth (USA) |
| Developed clay body that is compatible with the expansion rate of glass and fusing glass and clay together to create sculptural form with no visible crack |


Claire Phillips Thomas developed a series of work that combines slip cast ceramics, paper pulp and slumped glass. The ceramic is pierced at the leather hard stage and biscuit fired. The glass is then melted through the pierced holes to create runs of glass, resulting in colorful glass drips flowing through ceramic form. Claude Bromet fuse colored glass into the surface of high fired ceramic setter, resulting visible stresses and crackle effect can be seen. Emily Barber slump thick float glass to hand built ceramic mold as an integral part of the work to reveal the idea of the mold being part of the final piece, not just a vehicle for its making.

John Groth has developed a clay body that compatible with the expansion rate of glass. His art work fusing Bullseye glass with clay to create sculptural forms. Mustafa Ağatekin use ceramic materials as an inclusion material in his glass artworks by fusing different layers together with no visible cracks or stress can be seen in his work. Tiziana Bendall-Brunello uses garment to explore the fragility and the presence of the body. She creates delicate sculpture in slip cast porcelain over which she slumps sheet float glass, no visible cracks or stress can be seen in the surface of her work.

<table>
<thead>
<tr>
<th>Art Objects/Warm state assembled</th>
<th>Mustafa Ağatekin (Turkey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cam İçi Seramik 47</td>
<td>Using ceramic as inclusion</td>
</tr>
<tr>
<td>Fusing different layers together with glass sheet, no visible cracks</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Art Objects/Warm state assembled</th>
<th>Tiziana Bendall-Brunello (Italy) 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragments 48</td>
<td>Slip cast porcelain</td>
</tr>
<tr>
<td>Slump sheet float glass</td>
<td>No visible cracks</td>
</tr>
</tbody>
</table>


### 2.2.3 Hot state assembled

#### Table 18 Detail of Art Objects/Hot state assembled

<table>
<thead>
<tr>
<th>Art Objects/Hot state assembled</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Alfred Spivack (USA) 2007**  | Biscuit fired thrown stoneware  
|                                | Fused coloured dichroic glass  
|                                | Combined in hot stage, slight cracks can be seen |
| **Amy Lemaire (USA) 2006**    | Bead making techniques to fuse soda lime glass to high alumina stoneware ceramic forms in hot stage with no visible crack |
| **David Binns (UK) 2008**     | Kiln cast glass & composite mix of ceramic aggregate which was fired into large scale sculptures with no visible crack |
| **Felicity Aylieff (UK) 1996**| Hand formed White Clay with aggregates of fired Porcelain and Black porcelain, terracotta clay, borosilicate glass and ballotini which was fired into large scale sculptures with no visible crack |


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50 Source: http://amylemaire.com/  

51 Source: http://www.davidbinnsceramics.co.uk/  

52 Source: http://www.aylieff.com/  
### Table 19 Detail of Art Objects/Hot state assembled

<table>
<thead>
<tr>
<th>Art Objects/Hot state assembled</th>
<th>Source</th>
</tr>
</thead>
</table>
| **Wedge glass sculpture**<sup>53</sup> | Jessamy Kelly (UK) 2009  
Developed bone china clay body that is compatible with the expansion rate of glass and firing kiln cast glass and clay together to create sculptural form with no visible crack |
| **Geological Formations**<sup>54</sup> | Sally Resnik Rockriver (USA)  
Blown glass with dried ceramic glazes  
Hot stage chemical reactions / fuse, melt, and crystallize. |
| **Exploded Earth**<sup>55</sup> | Steve Tobin (USA)  
Explosive into raw clay as explosion takes place spheroid forms then fired with glass as its core in a hot stage.  
A distinct crackle effect can be seen |

Source: Researcher’s table, June, 2017.

In this group, artworks are combine ceramic and glass together in high temperature. Alfred Spivack has developed a technique which fuses colored dichroic glass to biscuit fired thrown stoneware vessels which he combines in hot state. Slight cracks and stresses can be seen in the surface of his works. Amy Lemaire employs bead making techniques to fuse soda lime glass to her high alumina stoneware ceramic forms in a hot state.

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David Binns adds glass to his composite mix of mineral aggregates, which he fires into large scale sculptures. The process involves kiln casting waste mineral aggregates such as grog, granular refractory materials and found materials which he combines with recycled glass in hot state. In similar is that of Felicity Aylieff which she combined small pieces of glass and aggregates in her large scale ceramics and fired in high temperature.

A contrasting approach is that of Sally Resnik Rockriver, who generates hot state chemical reactions in her blown glass and ceramic artworks. She creates geochemical formation through high temperature crystal growth. She started using melted glass on her ceramic to form crystalline glazes and she started applying ceramic glazes to hot blown glass.

Steve Tobin works in a range of materials including bronze, steel glass and clay. To make his ceramic works he sets explosives into raw clay as the explosion takes place spheroid forms are created; the work is then fired with glass as its core in a hot state. A distinct crackle effect can be seen on the surface of his works.

Dr. Jessamy Kelly developed bone china clay body that is compatible with the expansion rate of glass and firing kiln cast glass and clay together to create sculptural form with no visible crack. The researcher uses the artworks and doctoral thesis “The combination of glass and ceramic as a means of artistic expression in studio practice.” (University of Sunderland, 2009) of Dr. Jessamy Kelly as a research reference due to the characteristic of the developed bone china clay body that related with the objectives of this research.

2.2 Related Studies: Ceramic and Glass

1. Ceramic: According to the relevant literature review of a total 53 ceramics and glass artworks of designers and artists worldwide, the researcher conclude material and process of ceramic as the following diagram;
1. Ceramics

Terracotta, earthenwares, stoneware, porcelain and bone china, all kinds of clay bodies have been used to create ceramic work in various techniques such as...
hand forming, slip casting and 3D printing based on idea, design and how the artists want to express their artistic style of works through a diverse range of possibilities which extend from functional / useful pieces that continue a long tradition to works that have no concern with function. This research aims to experiment and create new possibilities for combining ceramic and recycled glass by solved compatibility issues in term of expansion and shrinkage rates when they are combined. And to create a new visual language and aesthetic value of combining ceramic and recycled glass for lighting design. Therefore the researcher decided to use bone china clay body refer to Dr.Jessamy Kelly developed bone china clay body that is compatible with the expansion rate of glass.

Bone china clay body is a type of porcelain that is composed of bone ash, feldspathic material, and kaolin. It has been defined as "ware with a translucent body" containing a minimum of 30% of phosphate derived from animal bone and calculated calcium phosphate. (Arthur Dodd & David Mufin, 1994) Bone china is the strongest of the porcelain or china ceramics, having very high mechanical and physical strength and chip resistance, and is known for its high levels of whiteness and translucency. Bone china biscuit firing at 1200 °C - 1300 °C and glost firing at 1050°C - 1100 °C.

In the experimentation process, the research at first tried to make bone china clay body in the formula: Bone ash 40% Kaolin 30% Feldspar 25% and Silica 5% from Department of Science Service (Ingsiriwat, 1998: 177) and added quartz silica sand to bone china clay body in various percentage to experiment and fine a compatible formula that can combine with glass. After the consulting with materials specialists Mrs.Varangkana Klinsukol, Head of Product Engineering, Kohler (Thailand) Public Company Limited on 22 April, 2017 suggested that the researcher should use the clay body manufactured form the company which are more standard in quality, reliable and stable more than the clay body making in the studio because bone china clay body require high refractory temperatures and specialized equipment beyond the technical constraints of the studio environment. Therefore the researcher approached to the Royal Porcelain Public Company Limited, the only one company in Thailand

that manufacture Bone china Product and received fully material support for the bone china clay body for this research. The experimentation process detail will be present in the chapter 4.

2. Glass

Figure 3 Diagram of Glass; material and process conclusion
Glass is a unique, amazingly versatile material transformed by fire into a unique transparent solid with marvellous optical qualities. Forms and images be suspended within it, or magnified through it. Glass can be toughened and coloured. (Layton, 1996: 10) There are infinite ways of formulating different types of glass according to the qualities required. The choice and proportion of the ingredients determine the visual and working properties of the resulting glass.

**Materials:** Glass can be made from pure silica which as one of the earth’s most plentiful resources is found as sand, quartz or flint. Glass products include three types of materials; formers, fluxes, stabilizers and colouring agent. (Layton, 1996: 106)

**Types:** Glass can be classified into a few general types; float glass, soda lime glass, lead glass, borosilicate glass, pure silica glass, pressed glass, flash glass and Kiln-forming glass. (Beveridge et al., 2005: 28-29) In this research use soda lime glass which is the most common produced for everyday items such as bottles, jars, light bulb and window glass. It’s base ingredients are sand, soda and lime. Other metals and metal oxide can be added to glass to render different colours or change its physical properties.

**Techniques:** Glass has many appealing characteristic, including fluidity, optical qualities, potential for detail and colour, and responses to light. There are many ways to create glass art and how it is possible to work creatively with all of these qualities. Glass blowing, Lampworking, Kiln-forming, cold working, stained glass and glass mosaic. From the literature review the research found out that Kiln-forming techniques are suitable and have potential possibilities to combine ceramic and glass together in firing process.

This research is a practice based research in the ceramics and glass discipline. While the researcher have a background in ceramics design but currently do not have the same for glass. In Thailand, there is no institution teaching glass art just only apart from short lampworking course at Bansai Royal Folk Arts and Crafts Centre and scientific glass blowing in a material science program at some universities. Because of the lack of places and personnel specialized in teaching glass art. The researcher have to study and learn glass technique by self-learning, by trial and error from the internet especially from youtube but cannot find the place provide facilities for glass
art to practice. The glass art materials also difficult to find and have to import from another country. Therefore in this research, recycled glass bottles and window glass were used because glass is ideal for recycling since none of the material is degraded by normal use. Glass bottles and jars are 100% recyclable and can be recycled endlessly without any loss in purity or quality.

3. Ceramics and Glass Relationship

![Diagram of Ceramic and glass relation; material and process conclusion. Source: Researcher’s diagram. June, 2017.](image)
Material

Ceramic: Bone china clay body + quartz silica sand added.
Glass: Soda lime glass, bottle and window glass.

Techniques

Ceramic: Hand forming
Combination with glass: Kiln-forming (fusing, slumping and casting)

In this chapter the research analyzed and concluded from literature review and related studies. The results are quartz added bone china clay body was identified and used for the experimentation due to its translucent quality and compatibility with glass. Recycled glass bottles and window glass will be used in the experimentation process. The kiln-formed techniques; fusing, slumping and casting will be used to create the prototype artwork to display the result of this research. Research methodology and the detail of the experimentation of ceramics and recycled glass combining technique will be present in the next chapter.
Chapter 3
Research Methodology

The research is a practice based research that can be split into two phases. The first phase focuses on research in Art and Design

1. To understand material and process and identify the possibilities of how to combine ceramic ad recycled glass through the literature review as described in chapter 2.

2. To study and develop new visual language and aesthetic value of combining ceramic and recycled glass by survey, collect and analyze data from fieldworks.

The second phase focuses on pure practice

1. To experiment materials and process of ceramic and recycled glass for potential compatibility and combining techniques

2. To express the concept design and create decorative lighting design of combining ceramics and recycled glass.

Figure 5 Diagram of research methodology
3.1 Research in Art and Design

The researcher has been working at the Office of Traditional Arts, Fine Arts Department, Ministry of Culture for 15 years and has personal interested in Thai Traditional Architecture. To display the result of the experimentation the researcher make a set of prototype artwork which the inspiration was drawn from “Star ceiling: patterns and elements from Thai Traditional Architecture”. The research collected the information from many sources such as related books of Thai architecture, survey to many temples, photograph the pattern and element of temple ceilings.

Figure 6 Photos of Star ceiling in Thai Architecture.
Photo of field work from temples in northern part of Thailand (May, 2017)

Wat Phumin, Nan
Wat Hua kwung, Nan
Wat Phra That Hariphunchai, Lampoon.

Figure 7 Photos of temples in Nan and Lampoon Province.
Figure 8 Photos of temple in Phitsanulok Province.

Figure 9 Photos of temples in Phrae and Lampang Province.


Wat Phra That Cho Hae, Phrae.

Wat Phra That Lampang Luang, Lampang.
Figure 10 Photos of temples in Chiang Mai Province.
The field work from many provinces in Northern part of Thailand, the researcher collected data, took photos and analyzed the decorating techniques of the ceiling and categorized into 4 groups as follow;

1. Wood carving and gold gilding.
2. Wood carving, gold gilding and glass mosaic.
3. Color painting.
4. Color painting and gold gilding.

The content of the ceiling decoration are varied, about Buddhist history, 12 Zodiac, lotus flower and pattern of Thai ornaments and motifs and etc.

3.2 Design Inspiration

Figure 11 Photo of Wat Benchamabopitr

Wat Benchamabopitr Dusitvanaram is one of the six temples in Bangkok given with the title of highest grade of the first class Royal temples, known as Racha-Vora-Vihan. Wat Benchamabophit or “The Marble Temple” as known to foreigners is most satisfactory architecturally with its symmetry and perfect proportions.
The Ordination Hall was built from Italy’s Carrara marble and had a distinct neoclassical European influence. It was designed by H.R.H. Prince Narisranuvattivongse, half brother to King Chulalongkorn, Rama V and has been reckoned for its finest Thai craftsmanship architectural and decorative arts.

Wat Benchamabopitr was founded by King Chulalongkorn, Rama V of the Chakri Dynasty, on 1 March 1900 (Dharmavarangkura C. 2000, p.4) The layout was very well-planned. Upon completing its planning and construction, the Uposatha Hall and its cloister become one of Thailand’s most beautiful temples and showcase the glorious architectural arts of Thailand to the world recognition.

Figure 12 Drawing of Wat Benchamabopitr
The Uposatha hall is a structure of the four-gabled style. The east gable extends in an oblong shape. The north and the south gables were connected to its cloister with four-tiered roof. The principal north and south gables are of five-tiered roof. Extended from both sides of the Uposatha Hall is its cloister, forming a square enclosure that takes in the rear part of the Uposatha hall. The Uposatha hall is not of great size. The designer prince explained that its size is proportional to the size of the main Buddha image PhraBuddhajinarajaenshrined.

Regarding the marbles used to decorate the Uposatha hall and its cloister, the designs, the colours and the sizes had been specified by H.R.H. Prince Narisranuvattiwongse with assistance of an Italian architect, Signor Mario Tamagno, who had been working with the Department of Public Works at that time. The marbles are of the finest quality from Carrara in Italy. Signor L. Mosso, an architect of the Novi Guiseppe Company, had come to help in decoration of marble on royal expenses.
Figure 14 Photos of Wat Benchamabopitr’s ceiling.
Figure 15 Photos of cloister’s ceiling
Figure 16 Photo of cloister’s ceiling

Figure 17 Photos of Thai pattern ornaments decoration of the ceiling.
Figure 18 Photos of Thai pattern ornaments decoration
Figure 19 Photos of Thai pattern “Thep panom” decorating in both stained glass window and wall painting.

The researcher was interested and inspired by how contemporary Wat Benchamabopitr was designed and decorated by using western materials and decoration techniques with traditional Thai ornament such as white Carrara marble from Italy decorated the main structure and decorating the detail of the architecture with Thai traditional wood carving and gold gilding technique and the window decorating with stained glass and Thai pattern of Thep panom which was ordered and imported from Italy. This temple is unique and distinctive presented how European architecture and Italian marble has been masterfully melded into the temples and religion of Thailand. In this research the simplification of Thais element from this temple will be used in the design to make contemporary artwork with the sense of Thainess and reflecting the artistic identity of the researcher.

There are few temples in Thailand decorate the window with stained glass technique such as Wat Niwet Thammaprawat

Figure 20 Stained glass decoration in Wat Niwet Thammaprawat, Ayutthaya. Source: https://www.tourismthailand.org/Attraction/Wat-Niwet-Thamprawat--24 Accessed August 28, 2019.
Wat Niwet Thammaprawat is considered in Thailand to be the one and only temple of European architecture. It is located on the Chao Phraya River island, on the bank opposite to the Bang Pa-in palace. In 1876, during his stay at Bang Pa-in Palace, King Rama V had this temple constructed to conduct religious practices. This monastery's interesting aspect is that it has been decorated in Western style. A Christian cathedral with steeply sloped Gothic roofs resembles the ordination hall (ubosot). The window was embellished by the main Buddha image with colorful stained glass depicting King Rama V's image.

Wat Chareonsamanakij in Phuket province decorate the door panel with stained glass technique, painting the image of guardian goddess in Thai traditional style.

Figure 21 Stained glass decoration in Wat Chareonsamanakij, Phuket. Source: http://picdeer.org/monet.glass  Accessed August 28, 2019.

Wat Thang Sai in Prachuap Khiri Khan province is a magnificent temple which was built in 1996 to mark the fiftieth year of reign of King Bhumibol Adulyade. It has 9 pagodas to honor His Majesty The King Rama IX and it can be seen sitting on top of Thong Chai Mountain just above Baan Grood Beach from the Big Golden Buddha. This temple decorate
the stained glass window showing His Majesty King Bhumibol Adulyadej’s tale of Mahajanaka. Mahajanaka's Story was published in 1996 on the auspicious occasion of His Majesty the King's Accession to the Throne's 50th Anniversary Celebrations. He wanted this story to become an object for all well-meaning people of constructive contemplation. Dhamma in Mahajanaka's Story is an encouragement for everyone to face problems in all circumstances with courage and perseverance.⁵⁷

Figure 22 Stained glass decoration in Wat Thang Sai, Prachuap Khiri Khan.

The researcher will use Thai elements from the star ceiling and simplify the Thai traditional forms into simple shape that can represent the contemporary Thai style in the prototype artworks made from ceramics and recycled glass. Most of Thai traditional patterns are originated from shape of Lotus flower and modified into many intricate and exquisite shapes.

The research collect data and shapes of the star ceiling form many temples in field work and will simplify those forms to make the sample that will be used in the experiment process in the next chapter.
3.3 Pure Practice

The researcher first implement bone china clay body testing to find out the suitable percentage of quartz silica sand which added into bone china clay body and then testing recycled bottle and window glass to find out melting temperature. The result of these two testing parts were used in combination process testing which the three process routes are categorized regarding to the conclusion from literature review and related studies.

![Diagram of combination process testing](source: Researcher’s diagram. July, 2017)

3.3.1 Combination Process Testing

**Process Route 1:** High fired ceramic setter fusing with recycled bottle and window glass.

In this process route, identified quartz added bone china clay body were fired in high temperature and used as a setter for ground, fragment, sheet recycled bottle and window glass then fusing together in the electric kiln.

**Process Route 2:** Recycled window glass combine with ceramic as an inclusion.

In this process route, high fired ceramic were used as an inclusion between two sheets of recycled window glass then fusing together in the electric kiln.
Process Route 3: Recycled bottle and window glass fragment casting with ceramic aggregate.

In this process route, high fired ceramic aggregate were put together with recycled glass bottle fragments in the mold and then casting together in the electric kiln.

These three process routes were used kiln-forming technique: fusing, slumping and casting to experiment.

3.3.2 Kiln-forming

Based on the principle that glass deforms (Bends ➔ Stretches ➔ Flow) under the influence of heat and gravity, Kiln-forming requires a careful approach to the preparation and organisation of components. Visual control of the firing cycle and an ability to predict the behaviour of the glass when heated are highly desirable for kiln forming process. (Griffith, 2007:12-13). Kiln-forming glass covers a wide range of techniques, materials, process and approaches to creating art and craft works.

Figure 25 Diagram of Kiln-forming techniques.
Fusing

The basic meaning of fusing is taking glass to a high enough temperature and for a long enough time for pieces to soften and then permanently bond together. There are 3 main fusing techniques; Tack fusing, Partial fusing and Full fusing.

Figure 26 Diagram of fusing

**Inclusions**: are anything added to or enclosed between other materials. Inclusions in glass are created by placing a piece of some material between two layers of glass, usually transparent. The fusion process laminates two type of glass and the material such as various forms of metal; thin wire or sheet of copper, silver, gold tin and iron, organic materials such as leaves, small branches and flowers.

**Slumping**

Bending or slumping glass is achieved by careful time and temperature control in a kiln. Bending happens at a lower temperature and needs to be watched carefully in order to capture just the right amount of movement, while slumping will happen at a higher temperature, when the glass is soft enough to relax and take up the form of a mould.

**Draping** (Free fall)

Draping glass is similar to slumping in term of temperatures required and the action of the glass, but instead of falling into a concave mould, the glass drapes around a convex mould.
Figure 27 Photos of fusing slumping and draping techniques.


Casting

Casting process starts with making a prototype and involves making a mould from materials that are able to withstand high heat (Refractory mould). Glass is loaded into the mould then placed in a kiln and heated up to the point where the glass melts into the exact shape and detail of the inside of the mould. Kiln casting includes a number of related methods; Open casting, Sand casting, Flower pot casting, Pâte de verre (Glass paste), Core casting, Lost wax casting and Lost vegetable casting.
Sand casting

Pâte de verre

Flower pot casting

Refractory mould packed with glass and going into kiln.

Figure 28 Photos of casting techniques.
Mould making

Pouring mould mix in one go is a straightforward way to make a mould. There are two approaches to mixing – wet and dry. Dry mixing is preferable as it improves mould strength through better homogeneity and particle distribution by effective mixing twice – before and after the materials are added to water. Wet mixing involves adding dry materials to water and then combining them together by stirring. The mixture will soon begin to thicken. Timing is important with wet mixing, to ensure good result.

The Stages of Firing

-Drying and pre-firing refractory mould Drying mould as much as is practical before any firing take place

-Initial heat-up The first stage of a firing is the initial heat-up, any residual water is driven off, so vent should be partially open to allow steam to escape

-Bubble Squeeze In fusing firings, the softening point is in the middle of the bubble squeeze stage. Moving slowly through the bubble squeeze stage and holding the temperature at the end of it allows time for the glass to succumb to gravity slowly, squeezing out most of the bubbles from between layers of glass and from between the glass and the kiln shelf.

-Process The process stage is the temperature range during which the real action of the firing takes place.

-Annealing The anneal stage is the stage of holding a constant temperature in the kiln in order to reach equilibrium in the glass temperature.

Fire Polishing

Fire polishing is the process of heating a glass piece that has a roughened surface (from grinding or sandblasting) just enough to soften the surface and make it shiny again.
In this chapter the research analyzed and concluded research methodology as present in figure 5. The first phase of research methodology focuses on research in Art and Design, the researcher studied materials and process of ceramics and recycled glass and surveyed to many temples in the provinces as following: Phare, Nan, Phitsanulok, Lampang, Lampoo and Chiangmai. (May, 2017) and Wat Benchamabopitr in Bangkok. (January, 2018) The result of the field works are that the researcher gained design inspiration and collected data to use in the experimentation and design development in the next chapter. The second phase of research methodology, the researcher can analyzed and concluded the experimentation of combination process testing into three process routes as mentioned in figure 24.

In next chapter the researcher will present the detail of the followings,

1. The experimentation of ceramic body and glass testing
2. The experimentation of combination process testing
3. The design process and design development to create the prototype artworks based on the result of the experimentations
Chapter 4
Experimentation and Design Development

4.1 Experimentation

The researcher implements the experiment by dividing it into two phases.

1. The first phase will experiment with material testing by separating the testing of clay body and glass to find the suitable clay body and temperature of glass melting. The result from this part will be used in the second phase.

2. The second phase will experiment with a combination process testing in three process routes as mentioned in chapter 3 and making experimental artworks with design development and testing with light. The result from this part will be used to design the prototype artworks.

4.1.1 The first phase: Material Testing


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<tr>
<td>Clay slip 100 cc + Silica 100 g *</td>
<td>15</td>
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<td>35</td>
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<td>65</td>
<td>75</td>
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<td>VCBS</td>
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-VCA/VCB * (Vitreous China) Ready-made porcelain of Compound Clay Co., Ltd.
-Clay slip 100 ml + Silica 100 g * from Jessamy Kelly, “The combination of glass and ceramics as a means of artistic expression in studio practice”, (Doctoral thesis, University of Sunderland, 2009), 93.
The researcher produces clay slip of bone china clay body following the formula from Department of Science Service as shown in Figure 29 and also use ready-made clay body from Compound Clay Co., Ltd. (VCA and VCB) Added silica powder into clay slip in various percentage as shown in table 20 and then casting clay slip into working mold to make the test pieces.

In casting process the researcher found the problem that slip clay bodies are not suitable for casting, plaster mold absorb slip clay very quick and the crack appear on the test pieces before the clay dry enough to take off from the mold as shown in figure 29.

Figure 29 Photos of bone china clay body testing.

2. Glass Testing

In glass testing process, the researcher collect recycled glass bottle from household, grocery store and collect window glass from window and door aluminum frame store. Glass bottle have four color; clear, brown, green and dark green. Window glass has three color; clear, dark brown, green and have various thickness.
Figure 30 Photos of recycled glass bottle and window glass.
2.1 Recycled Bottle Glass Fragment

**Melting Temperature Testing** (Fired in May-June, 2017)

Figure 31 Photos of glass melting temperature test pieces

The result of melting temperature testing found out that bottle glass was melt properly together at 1,100 °C which completely melt and still in shape not flow spreadly. Therefore in the combination process testing this temperature will be used to firing bottle glass with bone china clay body.

Figure 32 Photos of Melting Temperature Testing results

The researcher consulted with specialist in material science; Mrs.Varangkana Klinsukol (April 22, 2017) Head of Product Engineering, Kohler (Thailand) Public Company Limited, due to the problem found in test pieces casting process. She suggested the researcher should use ready-made bone china clay from standard factory instead because of the stability and reliability of the clay body controlled by factory laboratory. Therefore the research asking for research material support from Royal Porcelain Public Company Limited; the only company in Thailand that produce bone china clay body for their products.

The researcher mixed silica powder in ready-made bone china clay body in various percentage (refer to reference research of Jessamy Kelly, “The combination of glass and ceramics as a means of artistic expression in studio practice”, (Doctoral thesis, University of Sunderland, 2009) and make small test pieces firing with glass fragments in both separate different color and mixed color. The results are as shown in figure 33-34 as follow.
Figure 33 Photos of bone china clay body testing with green and clear bottle glass. Source: Researcher’s photos, May, 2017.
Figure 34 Photos of bone china clay body testing with brown and dark green bottle glass.

Source: Researcher’s photos, June, 2017.
Figure 35 Photos of the 1st bone china clay body testing results.

The first testing is to test the different of each color of recycled bottle glass when firing with testing ceramic clay body both rom Royal Porcelain Company and researcher own formula from figure 29. The researcher firing the test pieces for two times. The first time is to firing the clay body at 1,260 °C. Then put the glass fragments on the test pieces and firing at 1,100 °C. These select test pieces result shown in figure 35 have no crack appear in the test pieces but around one week later after firing, some of the test pieces have crack appear in the test pieces especially in the clay body that the researcher make from reference formula. Therefore the researcher make more test pieces from the selected results to fire again in the second testing and firing at the same temperature of the first testing.

From the result of the 1\textsuperscript{st} Clay body and glass testing, Test pieces number of B3, B5, B7, B9 and VCBS (from ready-made bone china) and 3, 4, 5 and 6 have been produce more and test with clear and mixed color bottle glass fragments.

![Image of Test Pieces]

Figure 36 Photos of the 2\textsuperscript{nd} bone china clay body testing results.
Source: Researcher’s photos, August, 2017.

This testing is to repeat and confirm the result of the first testing. The result are turn out that B3 and B5 are have no crack appear in the test pieces both clear and mixed color bottle glass fragments. Therefore the researcher take these percentage and make more specify test pieces between B3 and B5 to find more accurately and suitable percentage of silica sand powder that will use to mix with the clay body. The third testing will test of B2, B2.5, B3.5, B4 and B4.5 and firing at the same temperature of the first and the second testing.

From the result of the 2nd Clay body and glass testing, the research make more test pieces of B2, B2.5, B3.5, B4 and B4.5 firing with clear and mixed color glass fragments at the same temperature of the first and the second testing but adjust firing cycle in the anneal process to solve the problem that after firing for a week, some cracks appear in the test pieces which can assume that the anneal process are not properly done.

![3rd Clay body + Glass Testing Result](image)

Figure 37 Photos of the 3rd bone china clay body testing results.  

From the photos in Figure 37 shown that all of the test pieces firing clear glass with bone china clay body are have no crack in the test pieces but one week later after firing there are cracks appear in all of the test pieces except B4.5 still have no crack appear both clear and mixed color bottle glass test pieces. Therefore
the results of the third testing shown and confirmed that test piece of B4.5 is the most suitable to use in combination process testing in the second phase.

5. Recycled Glass Bottle Cutting in shape and Temperature testing (October – November, 2017)

In this testing, the researcher tried to find another way to use recycled glass bottle, not only just broke bottle glass into fragments but cutting it in shape can be useful in design process. Therefore the researcher studied how to cut bottle glass into circle and ring shape and firing at 850 °C which glass are not completed melt but still in shape of free form, curvy circle and ring shape.

Recycled Glass Bottle Cutting in shape & Temperature testing
( Fired in November, 2017 )

Figure 38 Photos of recycled glass bottle cutting in shape and temperature testing results.
In figure 39, the researcher tried to make various composition of glass bottle cutting into ring and curvy shape and firing together to experiment the possibilities that these combined shape can be after firing at 850 °C. The results can guide and adapt to use in design process of the prototype artwork.


For recycled window glass, the researcher use small broken pieces of window glass combine clear and green color, cutting into designed shape and firing for full fusing at 850 °C. This testing result are useful in design process and the researcher gain more experience in learning how to adjust firing cycle for glass which are different from firing ceramics.
Recycled window glass testing – fusing technique

Figure 40 Photos of recycled window glass testing – fusing technique results.

The results the first phase experiment of bone china clay body and glass testing can be concluded as following.

**Conclusion of material testing**

The first phase took about one year for materials testing. The result shown that B 4.5 : Ready-made bone china clay body from Royal Porcelain Company mixed with silica sand powder in following percentage are suitable to use in the next combination testing process.

- Bone china clay body biscuit firing at 1,260 °C and glaze firing at 1,100 °C.
- Bottle glass completed melt at 1,100 °C and partial fusing at 850 °C.
- Window glass full fusing at 850 °C and partial fusing at 750 °C.
4.1.2 The second phase: Combination Process Testing

**Process Route 1:**
High fired Ceramic setter

+ Recycled glass
  (ground / fragment / sheet)

Fusing/Slumping/Draping

Process Route 1: High fired ceramic setter fusing with recycled bottle and window glass.

In this process route, identified quartz added bone china clay body were fired in high temperature at 1,260 °C and used as a setter for ground, fragment, sheet recycled bottle and window glass then fusing together in the electric kiln at 750 °C - 850 °C.

Figure 41 Photos of some test pieces example for process route 1.
Source: Researcher’s photos, January, 2018
Process Route 2: Recycled window glass combine with ceramic as an inclusion.

In this process route, high fired ceramic were used as an inclusion between two sheets of recycled window glass then fusing together in the electric kiln at 750 °C - 850 °C.

Figure 42 Photos of some test pieces example for process route 2

Source: Researcher’s photos, July, 2018
Process Route 3: Recycled glass fragment casting with ceramic aggregate.

In this process route, high fired ceramic aggregate were put together with recycled glass bottle fragments in the mold and then casting together in the electric kiln at 1,100 °C.

Figure 43 Photos of test piece example for process route 3.
Source: Researcher’s photos, September, 2018.
The researcher implemented the second phase of combination process testing by using the result of the material testing from the first phase to make the experimental artworks which bring traditional Thai ornaments from design inspiration as mentioned in chapter 3 into design development.

4.2 Design Development

The researcher use the result from the experimentation to design and make experimental artworks as follow,

1\textsuperscript{st} design set: Process route 1, slumping technique
   For table lamp and wall hanging lighting set

2\textsuperscript{nd} design set: Process route 1, slumping technique
   For table lamp lighting set

3\textsuperscript{rd} design set: Process route 2, inclusion technique
   For wall hanging lighting set

4\textsuperscript{th} design set: Process route 3, casting technique
   For table lamp lighting set

5\textsuperscript{th} design set: Process route 1, slumping technique
   For ceiling lighting set

6\textsuperscript{th} design set: Process route 1, slumping technique
   For wall hanging lighting set

7\textsuperscript{th} design set: Process route 1 + Process route 2
   For screen and partition decorative

8\textsuperscript{th} design set: Process route 1 + Process route 2
   For mobile hanging lighting set

The researcher design all of the experimental artworks from the same concept and develop the design pattern, form and color combination of ceramic and glass and composition arrangement. The detail of every design sets will present in the following.
4.2.1 1st set of design experimentation. (Process Route 1)

Figure 44 Photos of design pattern of star ceiling form studying.
Source: Researcher’s photos, December, 2017

The researcher start working on 1st set of design experimentation by studying form of star ceiling observed from many temple in the northern part of Thailand which came from Lotus flower form and Thai traditional pattern such as Lai Prajumyam – name of Thai decorative pattern which consist of four flower leafs. And then simplified form into various simple shape. The researcher making test pieces by hand forming – slab forming technique and intend to put these test pieces in the kiln by using refractory brick stand and hand forming used clay to lift up the piece from the shelf ground to make the shape transform by gravity during the firing process.
Figure 45 Photos of refractory brick and hand forming clay stands
Source: Researcher’s photos, December, 2017.

**Process Route 1: Experimental works** (Fired in Oct-Nov, 2017)

The researcher making test pieces form silica added bone china clay body by hand forming – slab forming technique and cutting in designed shape. Then put the test pieces in the gas kiln by set on the refractory brick stand which are bigger than hand forming used clay stands. The advantage of hand forming used clay stands are that they are easy to set the height of the stand and control where to place the stand.

Figure 46 Photos of test piece setting on refractory brick stands firing with green bottle glass fragments and testing with light.
Source: Researcher’s photos, January, 2018
under the test pieces to firing into designed shape. The position of the stand have important effects on how the test pieces are transformed in the kiln. Therefore the research experiment various height and position of the stands to find suitable solution with various testing form. After firing the clay body at 1,260°C by gas kiln in reduction firing, then put bottle glass fragments on high fired clay body and firing again by electric kiln at 1,100°C. The results as shown in figure 47.

Figure 47 Photos of test piece setting on clay stands firing with clear and green bottle glass fragments and testing with light.

Source: Researcher’s photos, January, 2018
Figure 48 Photos of test piece setting on clay stands firing with brown bottle glass fragments and testing with light.

Source: Researcher’s photos, January, 2018
Figure 49 Photos of test piece setting on clay stands firing with mixed color bottle glass fragments and testing with light.

Source: Researcher’s photos, January, 2018
Figure 50 Photos of test piece in various forms after firing and testing with light.
Source: Researcher’s photos, April, 2018
Figure 51 Photos of test piece in various forms after firing and testing with light.
Source: Researcher’s photos, April, 2018
Figure 52 Photos of test piece in various forms after firing and testing with light.
Source: Researcher’s photos, April, 2018
From the result of Process Route 1 / 1st set of design experimentation, the research found out that the position of clay stand that are used to lift the test pieces form the shelf ground are very important and have a great impact on how the test pieces transform shape in firing process. If they are standing too close, shape of the test pieces are slightly change. If they are standing too far, shape of the test pieces are distorted and changed dramatically, some part of the test pieces are collapsed and torned. Furthermore in this set of design experimentation, the research also found out the effect of color bottle glass with light. The color of brown and green bottle glass are more darker than before firing especially in the area that glass are melted and flow together. The unpredictable shape of melting glass create new shape overlap on ceramic shape and different thickness of glass have different effect with light too. These effects can be seen vividly in figure 48.

In figure 50-52 shown result of various shape transformation testing with light. These test pieces are not firing with glass because of the pieces cannot carry fragment bottle glass. The researcher learned how to place clay stands to set the pieces into designed shape from firing these test pieces and gained new idea to develop the next design set.

4.2.2 2nd set of design experimentation. (Process Route 1)

In this design set, the researcher bring design inspiration from Thai ornament of ceiling decoration in Wat Benchamabopiti and simplified into simple circle and lotus leaf shape. The researcher intend to transform shape of these lotus leaf in the firing process. There is a hole in the circle to place window glass on this hole and make a glass dome as the middle of the circle in firing process as shown in figure 53.
All of test pieces clay body forms are flat slab form, not 3 dimensional. Therefore the researcher decide to experiment to put 2 pieces of clay between 2 sheets of window glass and firing together to combine them in firing process. This technique will help to make artwork more interesting in high relief form. Figure 55 present how to set the clay bodies on refractory brick and how the clay bodies stack
together with window glass sheets. In firing process two glass sheets will melt and mix together and slump to be a dome shape in the middle of the hole in the center of the clay bodies.

Figure 55 Photos of two test pieces combining together in firing process.
Source: Researcher’s photos, June, 2018
Figure 56 Photos of the artworks making by two pieces combining together in firing process.
Source: Researcher’s photos, June, 2018
Figure 57 Photos of the artworks making by two pieces combining together in firing process.

Source: Researcher’s photos, June, 2018
The researcher made several pieces by this technique and pick one piece to make a prototype artwork and make a light wood box to be the base of the artwork. The researcher put the artwork to stand in the gap between the line on light box to show both side of the artworks. The result with light turn out that the light from the wood box is too dark and cannot go through the clay body because the wood box design light to go through the box in small line shape. And the clay body is too thick to show the transparency quality of the bone china clay body.
4.2.3. 3\textsuperscript{rd} set of design experimenta\textit{tion}. (Process Route 2)

In this design set, the researcher bring design inspiration from Thai ornament of ceiling decoration in Wat Benchamabopitr and simplified into simple small flower leaf shape. There is no refractory brick stand use in firing process because the researcher want these flower leafs to be flat and smooth and easily to insert between two window glass sheets as an inclusion. The clear, green and dark brown are cut into circle and flower leaf shape and assembling together with high fired c quartz added bone china clay body by 2 or 3 layers in Thai traditional pattern. The results are as shown in figure 59.

Figure 59 Photos of design pattern of Process Route 2 / 3\textsuperscript{rd} set of design artwork.
Source: Researcher’s photos, July, 2018
Figure 60 Sketch design of Process Route 2 / 3rd set of design artwork.
Source: Researcher’s photos, July, 2018
The researcher assemble small test pieces together to be hanging mobile for lighting as shown in the paper model in figure 61. And bring the idea of hanging structure from the structure of the roof with fours gable end from Wat Benchamabopitr to make the example of the hanging mobile in actual size as shown in figure 62.

This design set is about 120 cm and have a lot of weight due to the weight of ceramic and glass. The problem is the joint between each piece are very fragile. The designed patterns were installed on a wall and tested with light. The result indicated that the structure of the joining point of glass and ceramic were not strong enough to be hung and would break easily.
Figure 62 The designed pattern when hung on the wall and size compared to the researcher standing in front.

Source: Researcher’s photos, September, 2018
Figure 63 Detail of the designed pattern and effect of the light to the artwork to see the transparency of clay body and colored window glass.

Source: Researcher’s photos, September, 2018
4.2.4. 4th set of design experimentation. (Process Route 3)

In this design set, the researcher put high fired ceramic in the biscuit fired ceramic bowl that been used as a mold for ceramic and glass casting. The mold were coated with alumina powder to help separated casting piece after firing. Then put clear bottle glass fragments in the bowl as shown in figure 64 and firing at 1,100°C. The result is the severe cracks in the test pieces make the casting pieces broken into pieces as shown in figure 65.

Figure 64 Photos of ceramic and glass casting test pieces.
Source: Researcher’s photos, April, 2018
In process route 1 and 2, thickness of bottle glass and window glass are around 3 mm. and use fusing and slumping technique. In this casting experiment thickness of glass melting together in ceramic mold are around 20 cm. The researcher assume that the thickness of glass casting is the reason of these severe cracks and broken the test pieces. The firing cycle that the researcher used in casting are not suitable enough. According to the research has no background in glass and learn to use kiln-forming technique in this research by trial and error. To learn how to cast glass are different from fusing and slumping and require more times to practice casting
Therefore the researcher decided to pursue the experiment in process route 1 and 2 because of limited time frame for this research and from the result of the experiment of process route 1 and 2 in 1st-3rd set of design experiment are sufficient to make the prototype artwork that achieve the purpose of this research.

4.2.5. 5th set of design experimentation. (Process Route 1)

In this design set, the researcher try to form the clay slab as thin as the pieces still have strength to hold themselves and show the transparency of the clay body by scratch the line to make pattern on the clay body. The pattern will be more thin than the other part of the pieces to show transparency quality of bone china clay body. The test pieces have a little hole around the edge for setting with light equipment to install from the ceiling.

![Figure 66 Photos of artworks with pattern of lines as a radius around the whole shape of the artworks.](source: Researcher’s photos, September, 2018)
Figure 67 Photos of the artwork hanging and testing with light installation.

Source: Researcher’s photos, September, 2018
4.2.6. 6th set of design experimentation. (Process Route 1)

This design set forming by the same technique of the 5th design set in bigger size and assembled together in groups with gradation sizes install on the wall with light setting at the back.

Figure 68 Photos of the artwork of the 6th design set installed on the wall.
Source: Researcher’s photos, October, 2018
Figure 69 Photos of the artwork of the 6th design set installed on the wall with light setting.

Source: Researcher’s photos, October, 2018

From figure 69 when install this design set with light setting, the light was too bright, especially in the glass dome in the middle of the artworks and the shape of 4 pieces are too similar and have no much related to each other in this design set.
4.2.7. 7th set of design experimentation. (Process Route 1 and 2)

In this design set, the researcher assembled the artwork from Process Route 1 and 2 together. The artwork of process route 1 forming by slip casting and perforated the design pattern on the pieces. First firing at 1,260 °C and then slumping clear window glass at 750 °C on top of the pieces to make the glass slump into the perforated pattern.

Figure 70 Photos of the artwork making by process route 1 in the 7th design set.
Source: Researcher’s photos, November, 2018
In process route 2, the researcher design the test pieces to be smaller and no protrusion part out of the form and assemble the test pieces to wood screen to combine all of small pieces to be one panel which can develop to be a partition and wall screen decorative pattern as show in figure 71.

Figure 71 Photos of the artwork making by process route 2 in the 7th design set.
Source: Researcher’s photos, November, 2018

Figure 72 Photos of the 7th design set assembled with the artworks made by process route 1 and 2
Source: Researcher’s photos, November, 2018
Figure 73 Photos of the 7th design set assembled with the artworks made by process route 1 and 2 with light setting.
Source: Researcher’s photos, November, 2018

Figure 74 Sketch design of some example patterns that process route 1 and 2 can assemble together to use as a partition or wall screen decorative.
Source: Researcher’s photos, November, 2018
4.2.8. 8th set of design experimentation. (Process Route 1 and 2)

The researcher develop this design from the 6th design set by simplified the form to be simple circle shape with ring pattern inside to present transparency quality of clay body. Forming the shape by hand forming- slab forming technique in thinner and smaller size than the artworks in the 6th design set. The Researcher made both one piece and 2 pieces firing together. Biscuit firing at 1,260 ºC then glazing all pieces with spraying and glaze firing at 1,100 ºC. The result as shown in figure 75.

Figure 75 Photos of the artwork made by process route 1 and decorated with gold gilding technique.
Source: Researcher’s photos, May, 2019
Figure 76 The example of gold gilding technique using to decorated the test pieces.
Source: Researcher’s photos, April, 2019

The researcher used Thai traditional gold gilding technique for quick result with the test pieces to experiment gold decoration effect in the design and plan to use gold painting in ceramic and firing in the kiln to decorative the final artwork.

Figure 77 Photos of the artwork made by process route 2 in this design set.
Source: Researcher’s photos, May, 2019
Figure 78 The example of the artwork that arrange the pieces from both process route 1 and 2 together.

Source: Researcher’s photos, May, 2019
Figure 79 Photo of the artwork setting with the mirror background to present the pieces in both sides.

Source: Researcher’s photos, May, 2019
The effect of light with clear and green glass color can be seen clearly in this design set from figure 77 which have variety and gradation of green color on white bone china clay and from figure 80 the pieces around the middle present transparency quality of bone china clay because they are near the light the center but the small pieces around the edge of the mobile set are not get enough light to present the gradation of light through the pieces.
4.2.9 Conclusion of experimental artwork design development

The researcher experiment combination process testing: process route 1-3 to design 1\textsuperscript{st}-8\textsuperscript{th} design sets of experiment artworks that can conclude as shown in the following tables.

Table 21 Conclusion of design development of 1\textsuperscript{st} -3\textsuperscript{rd} design sets.

<table>
<thead>
<tr>
<th>1\textsuperscript{st} design set.</th>
<th>The unpredictable shape of melting glass create new shape overlap on ceramic shape and different thickness of glass have different effect with light</th>
</tr>
</thead>
<tbody>
<tr>
<td>2\textsuperscript{nd} design set.</td>
<td>The light from the wood box base is too dark in small line shape and cannot go through the clay body. The clay body is too thick to show the transparency quality</td>
</tr>
<tr>
<td>3\textsuperscript{rd} design set.</td>
<td>The structure of the joining points of ceramics and glass are very fragile and not strong enough to be hanged and would break easily. The light testing with the paper model show that the light diffuse around too much cannot went through the test pieces directly</td>
</tr>
</tbody>
</table>

Table 22 Conclusion of design development of 4th - 8th design sets.

<table>
<thead>
<tr>
<th>Design Set</th>
<th>Description</th>
</tr>
</thead>
</table>
| 4th design set. | The severe crack cause the test pieces to separate in pieces  
The thickness of the glass are much more than slumping and inclusion technique and need more time to adjust and test to find suitable firing cycle |
| 5th design set. | The test pieces show more transparency of the clay body through the thinner area of the designed pattern |
| 6th design set. | The light testing show that the light was too bright especially in the glass dome in the middle and the shape of the test pieces are too similar and have no much related to each other in this design set |
| 7th design set. | The design of clay inclusion form are too small and cannot show transparency quality  
Pattern of the screen cannot present the design inspiration from Thai ornaments |
| 8th design set. | The light testing show that the light diffuse around too much cannot went through the test pieces directly  
The test pieces are very thin and can show transparency quality very well in the area that near the light source |

4.2.10 The Prototype Artwork No.1-3

The researcher have been working on 1st- 8th set of design experimentation and experienced how the form and the light effect on the design. This prototype are develop from advantages the researcher gather form all experiments and design to make a 3 dimension sculpture assembled from the art pieces of slumping and inclusion technique of process route 1 and 2 together in pentagon and hexagon shape to forming the sphere shape to gathering the light inside the form which can show the transparency quality of the clay body clearly through the design pieces with the light setting in the center as show in figure 81.

Figure 81 Sketch design for the prototype artwork.
Source: Researcher’s photos, May, 2019
Figure 82: Actual size model compared with the researcher standing in the back.
Source: Researcher’s photos, May, 2019
Figure 83 Sketch design of variety of the shapes and forms.

Source: Researcher’s photos, May, 2019
Figure 84 Sketch design of how to install process route 1 and 2 artworks.
Source: Researcher’s photos, May, 2019
Figure 85 Perspective design of the installation of the prototype artworks.
Source: Researcher’s photos, June, 2019
Figure 86 Mock up model for detail of process route 1 and 2 artworks positions in the pieces
Source: Researcher’s photos, June, 2019

Figure 87 Actual size steel structure with white color coating ready to install the process route 1 and 2 artworks
Source: Researcher’s photos, July, 2019
Figure 88 Photos of process route 1 and 2 artworks assemble together in pentagon and hexagon shape ready to install in the structures.

Source: Researcher’s photos, August, 2019
Figure 89 Photos of assemble process and light testing.
Source: Researcher’s photos, September, 2019
Figure 90 Photos of assemble process and light testing.
Source: Researcher’s photos, September, 2018
Figure 91 The prototype artwork No.1
Source: Researcher’s photos, October, 2019
Figure 92 The prototype artwork No.2
Source: Researcher’s photos, October, 2019
Figure 93 The prototype artwork No.3
Source: Researcher’s photos, October, 2019
4.2.11. The Prototype Artwork No.4

This work use process route 2: inclusion technique to make simple circle shape of bone china clay body combine with clear and green window glass sheet in various sizes and assemble together in metal frame. Inside metal frame have metal curve line as shown in figure 94 represent the idea of universe and star ceiling in Thai traditional architecture. This prototype also brought inspiration of stained glass from window of Wat Benchamabopitr Dusitvanaram which ordered stained glass and imported from Italy but the pattern of the stained glass are Thai traditional pattern. After assembled the art pieces on the metal frame, the researcher painting designed pattern with the glass painting color on the surface of the art pieces as shown in figure 95.

Figure 94 Sketch design of the prototype artwork no.4
Source: Researcher’s photos, September, 2019
Figure 95 Sketch design of the prototype artwork no.4
Source: Researcher’s photos, September, 2019
Figure 96 Assembling and painting process of the prototype artwork no.4
Source: Researcher’s photos, October, 2019
Figure 97 The prototype artwork No.4

Source: Researcher’s photos, October, 2019
4.2.12. The Prototype Artwork No.3

This artwork, the researcher design 3 dimensional form of cone shape which are assembled from small circle shapes in various sizes by hand forming technique. Firing the clay body at 1,260 °C. Setting with window glass sheet in electric kiln as shown in figure 99 and firing at 750 °C. Window glass sheet will slumping into free form surround ceramics setter.

Figure 98 Forming process of the prototype artwork No.5
Source: Researcher’s photos, September, 2019
Figure 99 Firing process of the prototype artwork No.5

Source: Researcher’s photos, September, 2019
Figure 100 The prototype artwork No.5
Source: Researcher’s photos, October, 2019
Figure 101 The prototype artwork No.5
Source: Researcher’s photos, October, 2019
Figure 102 The prototype artworks display in the PHD#8 Final Thesis Exhibition
At Arts Gallery at Ban Chao Phraya, Bangkok.
Source: Researcher’s photos, October, 2019
4.3 Conclusion of experimentation and design development.

Material testing (February – November, 2017)

- The result of materials testing shown that B 4.5 : Ready-made bone china clay body from Royal Porcelain Company mixed with silica sand powder in following percentage are suitable to use in combination testing process.

| Bone china clay body : Silica sand powder | 100 : 45 |

- Bone china clay body biscuit firing at 1,260 °C and glaze firing at 1,100 °C.
- Bottle glass completed melt at 1,100 °C and partial fusing at 850 °C.
- Window glass full fusing at 850 °C and partial fusing at 750 °C.

Combination process testing (December, 2017 – April, 2018)

The researcher implemented all three process routes of the combination process testing and made 8 design sets of lighting design experimental artworks. According to research time frame, the researcher can achieved process route 1 and 2 and decided to use slumping and inclusion techniques to create the prototype artwork to present the result of this research. For process route 3: casting technique required more time to study and experiment to find suitable firing cycle that can combine ceramics and recycled glass together without crack and stress in the art pieces.

Obstacles

In two years and a half of material and combination process testing, the researcher found out that the most difficult problem is to find the suitable firing cycle to firing ceramics and recycled glass together without compatibility problem. Ceramics firing process are depends on type of clay body and glaze that have been used. Glass firing process is different from firing bone china clay body on how to control the cool down period of firing. Therefore it’s difficult to find the proper firing cycle. Even the developed bone china clay body form material testing still have some cracks and stress appear in the art pieces as shown in figure 103.
Figure 103 Cracks and stresses appear in the test pieces.
Source: Researcher’s photos, June, 2018

The researcher have been firing more than one hundred times during three
years implementing this research and can adjust suitable firing cycle as shown in the
following.

Firing cycle for combine ceramic and recycled glass in slumping and
inclusion technique

- **Heating** 75-100 °C /hr. to 750-800 °C soak for 5-8 minutes
- **Cooling** 100 °C /hr. to 600 °C
- **Cooling** 10 °C /hr. to 515 °C soak for 15-20 hours
- **Cooling** 15 °C /hr. to 100 °C

After firing process around 20% of the test pieces still have some cracks
appear between ceramic and recycled glass and few weeks later some cracks happen
more on the test pieces. The researcher review and analyze the experimentation
process and make the assumption as followings,
1. The bone china clay body from Royal Porcelain Company are prepared and mixed with quartz silica sand again and produce in studio practice of the researcher, not in laboratory lab with standard quality as in industry production that can cause unstable result of the clay body after firing with recycled glass.

2. Recycled bottle and window glass using in the experimentation are from various sources that the researcher collected from household using and many window framing stores in Nakorn Prathom and Ratchaburi province. Different manufacture can cause unstable and different results even though the firing cycle are the same.

3. The annealing of the glass in firing process are not good enough that are the reason why some cracks still happen after firing the test pieces for few weeks later.

**Design development**

In the combination process testing of process route 1, 2 and 3, the researcher made 1st – 8th set of design to experiment how natural kiln effect transformed shape and form of the artworks in the kiln and how the light effect on the design artworks.

The researcher use art theory “The Significant Form” of Clive Bell “In each lines and colours combined in particular way, certain forms and relations of forms, stir our aesthetic emotion. These relations and combinations of lines and colours, these aesthetically moving forms, I call “Significant Form” and “Significant Form” is the one quality common to all works of visual art.”(Bell, 1914: 8) The conclusion of these design sets are shown in table 21-22

The researcher gathering experiences in forming and firing process, develop the design and make the prototype artworks as show in figure 91-93, 97, 100 and 101. The prototype artworks present transparency quality of bone china clay body and interesting gradation of green color of recycled bottle and window glass by effect of lighting on the artworks clearly as shown in the following.
Figure 104 Form transformation, translucency of ceramics clay body and the gradation color of glass and when install with light.

Source: Researcher’s photos, October, 2019

In the next chapter the researcher will conclude all of the aspect of chapter 1-4 in this research and the suggestion.
Chapter 5
Conclusion and Suggestion

In this chapter, the researcher will summarize the content of the research from the beginning, the literature review, research methodology, materials and process experimentation and design development into body of knowledge as the followings,

5.1. Literature Reviews Analysis

From the chapter 2 content, the combination of ceramics and glass have been implemented before from ceramics and glass artists and designers around the world. Many techniques have been used from cold state assembled, warm state assembled and hot state assembled to present the artworks form design to fine art as described in detail in chapter 2. The researcher presume that the reason why many designers and artists are trying to combine these two material together are because of the charming characteristic of ceramics and glass which can create artworks from various techniques and the advantage of using almost the same facility and equipment of the production of ceramics and glass. From the total 53 artworks can assumed that the design group, ceramic and glass are produced separated and combine ceramic and glass in cold state assembled for practical functional use of the product while the fine arts group use various kinds of clay and glass with all technique to present artists ideas and characteristics of the artworks regardless the incompatibility problem of ceramics and glass.

This research reference on one of case study in literature review which is the doctoral thesis “The combination of glass and ceramic as a means of artistic expression in studio practice.”(University of Sunderland, 2009) of Dr.Jessamy Kelly due to the characteristic of the developed bone china clay body casting with glass that related with the objectives of this research.
In this research, the researcher try to explore the possibilities to solve the incompatibility problem by implemented experimentation on materials and process testing which are analysed from the literature review and categorized into three process routes of combination process testing and making the prototype artwork to present the results of the experimentation.

5.2. The Experiment Conclusion

The research experimentation can summarized into these following,

5.2.1. Bone china clay body added with quartz silica sand in proportion of 100:45 are suitable to combine with recycled bottle and window glass. Bone china clay body biscuit firing at 1,260 °C and glaze firing at 1,100 °C. Bottle glass completed melt at 1,100 °C and partial fusing at 850 °C. Window glass full fusing at 850 °C and partial fusing at 750 °C.

5.2.2 The researcher implemented all three process routes of the combination process testing and made 8 design sets of lighting design experimental artworks. According to research time frame, the researcher can achieved process route 1 and 2 and decided to use slumping and inclusion techniques to create the prototype artwork to present the result of this research. For process route 3: casting technique required more time to study and experiment to find suitable firing cycle that can combine ceramics and recycled glass together without crack and stress in the art pieces.

5.2.3 The researcher found out that the most difficult problem is to find the suitable firing cycle to firing ceramics and recycled glass together without compatibility problem. Ceramics firing process are depends on type of clay body and glaze that have been used. Glass firing process is different from firing bone china clay body on how to control the cool down period of firing. Therefore it’s difficult to find the proper firing cycle. In two years and a half of material and combination process testing, the researcher can adjust suitable firing cycle as shown in the following.
Firing cycle for combine ceramics and recycled glass in slumping and inclusion technique

- Heating: 75-100 °C/hr. to 750-800 °C soak for 5-8 minutes
- Cooling: 100 °C/hr. to 600 °C
- Cooling: 10 °C/hr. to 515 °C soak for 15-20 hours
- Cooling: 15 °C/hr. to 100 °C

5.2.4. After firing process around 20% of the test pieces still have some cracks appeared between ceramic and recycled glass and few weeks later some cracks happen more on the test pieces. The researcher review and analyze the experimentation process and make the assumption of the cracks problem as followings,

5.2.4.1 The bone china clay body from Royal Porcelain Company are prepared and mixed with quartz silica sand again and produce in studio practice of the researcher, not in laboratory lab with standard quality as in industry production that can cause unstable result of the clay body after firing with recycled glass.

5.2.4.2 Recycled bottle and window glass using in the experimentation are from various sources that the researcher collected from household using and many window framing stores in Nakorn Prathom and Ratchaburi province. Different manufacture can cause unstable and different results eventhough the firing cycle are the same.

5.2.4.3 The annealing of the glass in firing process are not good enough that are the reason why some cracks still happen after firing the test pieces for few weeks later.

5.2.5. In firing process, the position of the test pieces are important and have impact to the transformation of the test pieces; how the clay body and glass will transform shape and form in the firing process. Because temperature in the kiln are not the same in all area but have few different depends on the size of the kiln and the firing process in the kiln. For example temperature in the top area of the electric kiln normally will higher than the bottom area of the kiln while firing. Therefore the glass test pieces on the top area of the kiln will have more melted shape than the test pieces on the bottom of the kiln.
5.2.6 In process of firing bone china clay body, the research found out that the position of clay stand that are used to lift the test pieces form the shelf ground are very important and have a great impact on how the test pieces transform shape in firing process. If they are standing too close to each other, shape of the test pieces are slightly change. If they are standing too far, shape of the test pieces are distorted and changed dramatically, some part of the test pieces are torned and collapsed.

5.2.7 The researcher found out that the effect of bottle and window glass after firing are more darker than before firing especially in the area that glass are melted and flow together. The unpredictable shape of melting glass create new shape overlap on ceramic shape and different thickness of glass have different effect with light too. These effects can be seen vividly in figure 48.

5.3. The Design Conclusion

The researcher has personal interested in Thai Traditional Architecture. To display the result of the experimentation the researcher make a set of prototype artwork which the inspiration was drawn from “Star ceiling: patterns and elements from Thai Traditional Architecture”. The researcher collected the information from many sources such as related books of Thai architecture, survey to many temples, photograph the pattern and element of temple ceilings.

The researcher was interested and inspired by how contemporary Wat Benchamabopitr was designed and decorated by using western materials and decoration techniques with traditional Thai ornament such as white Carrara marble from Italy decorated the main structure and decorating the detail of the architecture with Thai traditional wood carving and gold gilding technique and the window decorating with stained glass and Thai pattern of Thep panom which was ordered and imported from Italy. This temple is unique and distinctive presented how European architecture and Italian marble has been masterfully melded into the temples and religion of Thailand. In this research the simplification of Thais element from this temple will be used in the design to make contemporary artwork with the sense of Thainess and reflecting the artistic identity of the researcher.
The researcher use art theory “The Significant Form” of Clive Bell “In each lines and colours combined in particular way, certain forms and relations of forms, stir our aesthetic emotion. These relations and combinations of lines and colours, these aesthetically moving forms, I call “Significant Form” and “Significant Form” is the one quality common to all works of visual art.” (Bell, 1914: 8) The researcher design simple form inspired by Thai elements and natural kiln effects in firing process transform that simple form into new form which the researcher predict and make it happen from experiences in many firing experiments. Somehow ceramics has a charming quality the researcher impressed that is we cannot know all the results of the ceramic artwork until the firing finished. The excitement and anticipation when we opening the kiln door to see the result is enchanting. The same simple circle shape can be transform into unique differences curvy lines to combine with melted glass form create the gradation color of translucency when install with light.

**The design development with light setting**

From the 1st design set to the 8th design set detail of design development and light setting can be seen clearly from the conclusion in table 21-22. Process route 1 and 2 are experimented and design developed to combine together and present the translucency of bone china clay body vividly with interesting how light effects on the gradation color of bottle and window glass on the artwork as shown in fig 105-106.
Figure 105 Visualization of design development with light setting.
Source: Researcher’s photos, January, 2018-November, 2018
Figure 106 Visualization of design development with light setting.

Source: Researcher’s photos, May-October, 2019
5.4. The Research Conclusion

The researcher have been working with ceramics for almost 25 years and recently gain more interest in glass. This research beginning from the researcher experimentation by trial and error with passion to expand unlimited possibilities of ceramic work combine with other materials. Glass seem to be the proper material because both have many related material qualities and can be processed in similar ways using same equipment such as kiln to firing the artwork. Although the structural differences of ceramic and glass related to their varying rates of expansion which creates incompatibility, in form of excessive cracks or stresses in the combined body but the result of this research present that there are many possibilities to combine ceramic and glass throughout possible experimentation of combination process testing. Incompatibility problem can be solved by using developed bone china clay body from material testing result and firing with glass in proper firing cycle.

The design development also presents how the researcher developed individual identity in the form of artistic expression which can be clearly seen from the prototype artwork. Even though the design inspiration are from Thai traditional ornaments which have systematical balance, formal, well-ordered and exquisite in detail with colorful decoration but the researcher brought the own identity of personal favorite to playing with form and use natural kiln effects to transform the clay body in firing process and choice of green color from bottle and window glass into the prototype artwork which are present in contemporary style with composition and arrangement of form and color in the identity way of the researcher.

5.5. Recommendation

5.5.1. Refer to unsuccessful experiment of process route 3 which the researcher still cannot achieve to firing the test piece in casting process. The researcher should study and experiment more on casting and other glass technique to search for more possibilities to combine ceramic and glass together.
5.5.2. The artworks made from process route 1 and 2 in this research are use slab hand forming technique to make thin slab ceramics shapes. The result of this technique, the art pieces are in flat and low relief, some pieces are almost in two dimensional. Therefore the researcher suggest that ceramics form can be experiment more on three dimensional form which can develop more interesting form to present more artistic expression.

5.5.3. The researcher found out that there are many possibilities to combine ceramic and glass together from cold state assembled to hot state assembled depending on the purpose of the artist or designer want to present. The researcher suggest that clay has more potential to be explore in many different challenge techniques to be combine with other materials not only glass.
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Research Methodology & Timeline

**Practice based Research**

- **Research in Art & Design**
  - To understand material & process and identify the possibilities of how to combine ceramic & recycled glass
  - Study and analyze / Literature review
  - To study and develop new language & aesthetic value of combining ceramic & recycled glass
  - Fieldworks (survey / collect / analyze)
  - Inspiration & design development

**Synthesis & Experiment**

- **Pure Practice**
  - To experiment materials & process of ceramic & recycled glass for potential compatibility and combining techniques
  - Bone china body testing
  - Recycled glass testing
  - Combination Process testing
  - Process Route 1
  - Process Route 2
  - Process Route 3

**Making experimental art work**

- To express the concept design and create innovative design of combining ceramic & recycled glass for lighting design
- Design analysis and development
- Making art work

**Making experimental art work**

- Conclusion and make prototypes artworks
- VIVA Examination
- Making Prototype art work

**Semester**

- 1st (2016)
- 2nd (2017)
- 3rd (2017)
- 4th (2018)
- 5th (2018)
- 6th (2019)
- 7th (2019)
## Research Time plan

<table>
<thead>
<tr>
<th>Time Plan Description</th>
<th>Semester</th>
</tr>
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<tbody>
<tr>
<td>Literature Review and Related Studies</td>
<td></td>
</tr>
<tr>
<td>Experiments Analysis: Materials and Techniques</td>
<td></td>
</tr>
<tr>
<td>Experimental Artworks and Design Development</td>
<td></td>
</tr>
<tr>
<td>Design Analysis and Conclusion</td>
<td></td>
</tr>
<tr>
<td>Making the Prototype Artworks</td>
<td></td>
</tr>
<tr>
<td>Write Up, VIVA examination, Thesis Exhibition</td>
<td></td>
</tr>
</tbody>
</table>
Material Testing Timeline and Conclusion

1st Bone China Clay Body testing
(Prepared in February-May, Fired in June-July, 2017)

→ Hand forming
= Slab and cut into shape

2nd Bone China Clay Body testing
(Prepared in July-August, Fired in September, 2017)

→ A : Recycled Glass Fragment Melting Temperature testing
( May-June, 2017 )

→ B : Recycled Glass Cutting in shape & Temperature testing
( November, 2017 )

3rd Bone China Clay Body testing
(Prepared in September-October, Fired in November, 2017)

→ Bone China + Silica sand (100:45) + Bottle Glass firing at 1,100°C
- Biscuit firing at 1,260 °C
- Glaze firing at 1,100 °C
- Window Glass firing at 750°C

Ceramic Clay body

This research received full support of around 300 kg. Bone china clay body from Royal Porcelain Company.
Silica sand powder from
Pathomwathanapanit Mining Co., Ltd.
22 Moo 3 Wangtakoo, Amphur Muang,
Nakornpathom Province. 73000

Specification

Mineral: Silica Sand
Code: SD325
Finess: 325 Mesh (Residue (Max.)=3%)
Lot No.: -

Chemical Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Tg.Loss (%)</td>
<td>0.1-0.2</td>
</tr>
<tr>
<td>SiO$_2$ (%)</td>
<td>98.0-99.5</td>
</tr>
<tr>
<td>Fe$_2$O$_3$ (%)</td>
<td>0.03-0.07</td>
</tr>
<tr>
<td>Al$_2$O$_3$ (%)</td>
<td>0.02-0.06</td>
</tr>
</tbody>
</table>
Recycled Bottle Glass

The researcher collected recycled bottle glass from household using and recycled shop.

Recycled bottle glass with various granulation.
Recycled Window Glass

The researcher collected recycled window glass from Aluminium door and window framing store in Nakorn Prathom and Ratchaburi province.

Window framing store in Ratchaburi Province.

Window framing store in Ratchaburi Province.
Combination Process Testing

Process Route 1: Slumping

**Firing cycle** to combine ceramics and recycled glass in
slumping technique.

- Heating: 100 °C /hr. to 750-800 °C soak for 5-8 minutes
- Cooling: 100 °C /hr. to 600 °C
- Cooling: 10 °C /hr. to 515 °C soak for 10-15 hours
- Cooling: 15 °C /hr. to 100 °C

The photos to present detail of Process route 1.

Process Route 2: Inclusion

Firing cycle to combine ceramics and recycled glass in Inclusion technique

<table>
<thead>
<tr>
<th>Process</th>
<th>Temperature/Rate</th>
</tr>
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<tbody>
<tr>
<td>Heating</td>
<td>75 °C/hr. to 800 °C soak for 5 minutes</td>
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<tr>
<td>Cooling</td>
<td>100 °C/hr. to 600 °C</td>
</tr>
<tr>
<td>Cooling</td>
<td>10 °C/hr. to 515 °C soak for 15 hours</td>
</tr>
<tr>
<td>Cooling</td>
<td>15 °C/hr. to 100 °C</td>
</tr>
</tbody>
</table>

The photos to present detail of Process route 2.

Process Route 3: Casting

Firing cycle to combine ceramics and recycled glass in casting technique

Heating 100 °C /hr. to 1,100 °C soak for 5 minutes
Cooling 100 °C /hr. to 600 °C
Cooling 10 °C /hr. to 515 °C soak for 30 hours
Cooling 15 °C /hr. to 100 °C

The photos to present detail of Process route 3.
Source: Researcher’s photos. April, 2018.
25 ถุนภาคม 2562

เรื่อง แจ้งผลการพิจารณาบทความเพื่อสังคมนิพัทธ์เฉพาะในวารสารวิชาการ Veridian E - Journal, Silpakorn University สาขาวิชาศิลปศาสตร์ สังคมศาสตร์ และศิลปะ ปีที่ 12 ฉบับที่ 1 เดือนมกราคม – ถุนภาคม 2562

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ตามที่ทำการได้ส่งบทความเรื่อง “Possibilities of combining ceramics and recycled glass for decorative lighting design” เพื่อพิจารณาจัดพิมพ์เผยแพร่ ในวารสารวิชาการ Veridian E - Journal, Silpakorn University สาขาวิชาศิลปศาสตร์ สังคมศาสตร์ และศิลปะ ปีที่ 12 ฉบับที่ 1 เดือนมกราคม – ถุนภาคม 2562 นี้

ในการนี้ จึงแจ้งข้อความว่า เพื่อขอให้ทราบว่าบทความดังกล่าวได้ผ่านการพิจารณาจากคณะกรรมการที่มีเรื่อง เทียบเท่าใครได้พิมพ์เผยแพร่ ในวารสารวิชาการ Veridian E - Journal, Silpakorn University สาขาวิชาศิลปศาสตร์ สังคมศาสตร์ และศิลปะ ปีที่ 12 ฉบับที่ 1 เดือนมกราคม – ถุนภาคม 2562 บันทึกรายละเอียดการเผยแพร่ได้

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PUBLICATION Veridian E-Journal